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Idaho, Minidoka

Preliminary report on

GROUND WATER IN MINIDOKA COUNTY, IDAHO

with special reference to

THE NORTH SIDE PUMPING DIVISION OF THE MINIDOKA PROJECT 1948

By Raymond L. Nace
U. S. Geological Survey

Prepared in cooperation with the

IDAHO DEPARTMENT OF RECLAMATION
Mark R. Kulp, State Reclamation Engineer

and the

U. S. BUREAU OF RECLAMATION
R. J. Newell, Director, Region I

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DEPARTMENT OF THE INTERIOR
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GEOLOGICAL SURVEY

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GROUND WATER FOR IRRIGATION IN MINIDOKA COUNTY, IDAHO, DESCRIBED

A large supply of ground water is available for irrigation in the southern part of Minidoka County, Idaho, according to a report released today by Director William E. Wrather of the United States Geological Survey. The area described in the report is a typical part of the central Snake River Plain. The northern part of Minidoka County is an elevated, largely uninhabited plain. The central and southern parts include bottom lands of lakes and streams that have been irrigated extensively from streams, and higher bench lands that could be irrigated by means of wells. The wells drilled so far have yields as high as 4.5 cubic feet per second, with only small drawdowns in water level.

The water is part of a large body of ground water that is moving generally westward through the lava rocks of this part of the Snake River Plain, to discharge ultimately in large springs along the north wall of the Snake River Canyon in the 75-mile stretch between Milner and Bliss. The productiveness of the water-bearing lava rocks in the Snake River Plain as a whole is well known from previous investigations, but the report on Minidoka County is the first confirming the availability of a large amount of water there. Preliminary estimates indicate that sufficient water may be available to irrigate more than 66,000 acres of new land in the Minidoka Reclamation Project, and more than 20,000 acres of private lands. Additional hydrologic studies are needed to determine more precisely the amount of water that can be withdrawn efficiently.

The water withdrawn from wells in Minidoka County will represent salvage of water, a part of which otherwise would escape to the Snake River. The present spring discharge between Milner and Bliss exceeds 5,000 cubic feet per second. The extent to which the spring discharge may be affected by withdrawal of ground water in Minidoka County cannot be determined accurately on the basis of available data, and the report proposes additional studies to clarify this point.

The report is entitled "Preliminary report on ground water in Minidoka County, Idaho, with special reference to the North Side Pumping Division of the Minidoka Project." It was prepared by R. L. Nace, geologist, as a part of the regular co-operative investigations of the ground-water resources of the State by the Idaho Department of Reclamation and the Geological Survey, and under special cooperative arrangements with the United States Bureau of Reclamation. It contains a resume of the geology, tables and well data and logs and of chemical analyses of water, and a map showing the shape and position of the water table by means of contour lines. Multilithed copies of the report are included as an appendix to the 1948 report of the Bureau of Reclamation on the Snake River Basin. Copies are on file for public inspection with the Idaho State Reclamation Engineer, State House, Boise, Idaho; the United States Geological Survey, 429 Federal Building, Boise, Post Office Building, Idaho Falls and 2209 Federal Works Building, Washington, D. the Minidoka Irrigation District, Rupert, Idaho; the Burley Irrigation District, Burley, Idaho; and several public libraries in the area. A few copies are available for distribution from the Boise office of the Geological Survey.

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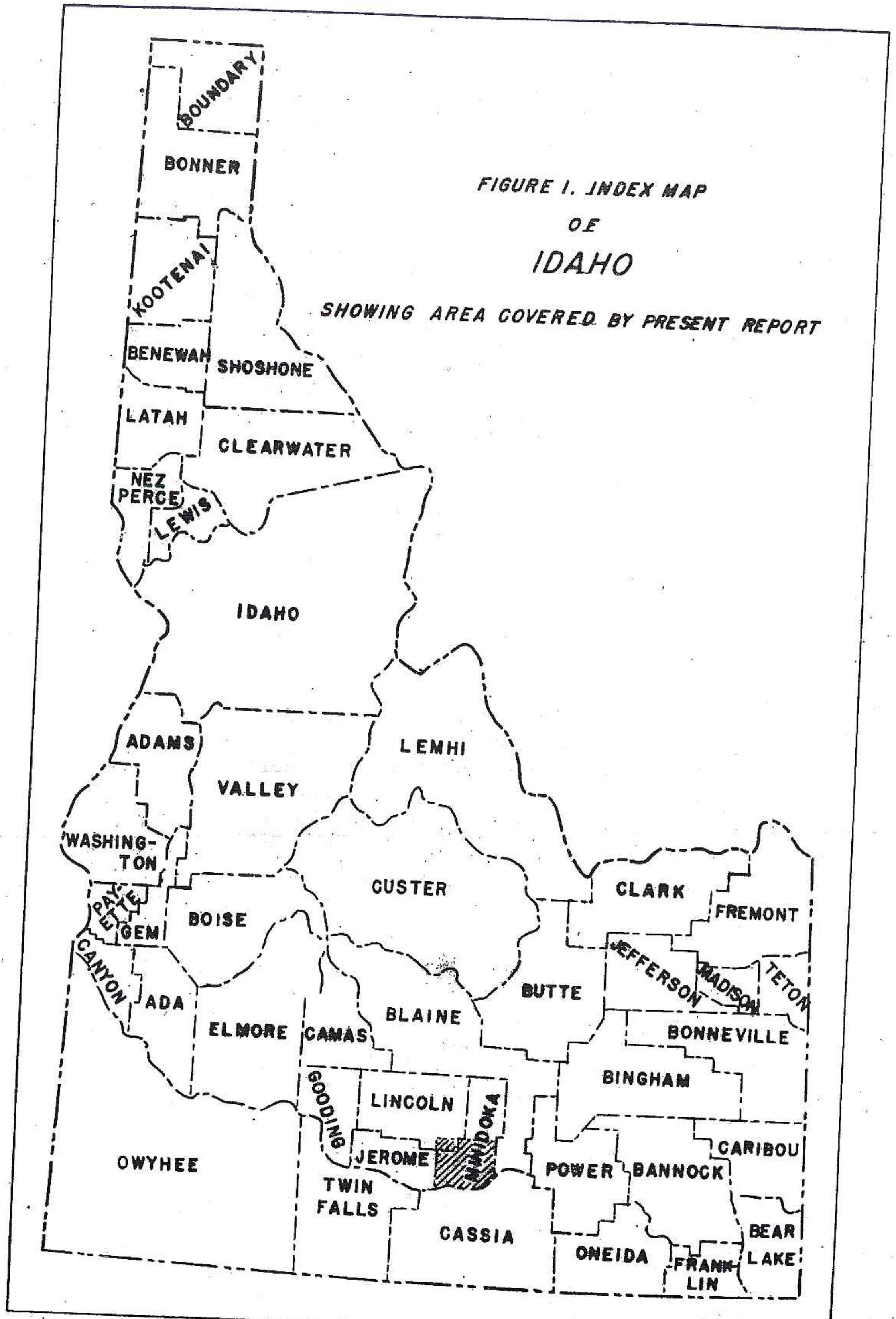
FIGURE I. INDEX MAP
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IDAHO
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BONNER
KOOTENAI
BENEWAH
SHOSHONE
LATAH
CLEARWATER
NEZ PERCE
LEWIS
IDAHO
ADAMS
VALLEY
LEMHI
WASHING-TON
PAYETTE
GEM
BOISE
CUSTER
CLARK
FREMONT
JEFFERSON
MADISON
TETON
CANYON
ADA
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Preliminary report

on

GROUND WATER IN MINIDOKA COUNTY, IDAHO

with special reference to

THE NORTH SIDE PUMPING DIVISION OF THE MINIDOKA PROJECT

By Raymond L. Nace

ABSTRACT

Minidoka County, Idaho, includes an area of about 750 square miles in the central part of the Snake River Plain, a part of the Columbia Plateau lava ground-water province. The principal town and commercial center of the county is Rupert.

The chief purpose of the investigation here recorded was to obtain data concerning the source, movement, and quantity of ground water perennially available for irrigation in the vicinity of the Minidoka North Side Reclamation Project, with special reference to the North Side Pumping Division, an as yet undeveloped area of about 66,600 acres. The area has not previously been studied in detail. An areal geologic reconnaissance was made, samples of water were chemically analyzed, and numerous well records and published and unpublished data have been assembled and correlated. With the aid of these data and a system of levels, it has been possible to prepare a map of the area showing the contours of the water table and artesian-pressure surfaces and the directions of ground-water underflow. As the altitudes of the land surface of much of the area are known, it is possible with the aid of the map to predict the approximate depth at which a well will obtain water at a given location.

The average total discharge of proposed irrigation wells in the North Side Pumping Division would be about 1,030 second-feet; that from proposed wells in adjacent privately developed lands might amount to 290 second-feet. The total withdrawals of ground-water in and near the Minidoka North Side Pumping Division might therefore amount to about 1,300 second-feet during the 4 months of the irrigation season. The total average discharge of ground water from the Snake River Plain on the north side of the Snake River Canyon from springs and seeps between Milner and King Hill, is between 5,000 and 6,000 second-feet. The average discharge of proposed irrigation wells in the North Side Pumping Division will therefore amount to about 22 percent of the discharge of springs and seeps and will represent salvage of ground water that would otherwise be discharged to the river by springs.

The amount of ground water that can be perennially withdrawn from wells in the Pumping Division and contiguous areas appears to be limited only by the ability of the lava aquifers to transmit water from the regional body of ground water in the Snake River Plain to the areas of local withdrawal. Test wells and pumping tests that have been made indicate that irrigation wells can be pumped at rates in excess of 4.6 second-feet (2,100 gallons a minute each), with small or negligible drawdowns.

Data indicate that the main sources of ground water moving into the Minidoka North Side area by underflow are east of the area. The relations of Lake Walcott, at Minidoka Dam, to the regional water table have not been studied. It cannot be determined from existing data, therefore, whether or not the local ground-water reservoir is fed by seepage losses from the lake. This and other pertinent problems that require study are discussed in the present report.

INTRODUCTION

Location and General Features

Minidoka county, about 750 square miles in extent, is in the central part of the Snake River Plain in what Meinzer 1/ has called the Columbia Plateau lava ground-water province. The northern part of the county is an area of somewhat elevated lava plains, mostly uninhabited. It supports a moderate growth of sage-brush, grasses, and other plains vegetation; the land has been used for little except sheep and cattle grazing. The southern part of the county, which includes a flat alluvial plain adjacent to the Snake River, is one of the important agricultural areas of south-central Idaho. Minidoka County had a population of 9,870 in 1940. Rupert, the principal town and commercial center of the county, had a population of 3,167. Other towns and villages, with their populations, are Acequia;2/ Heyburn, 413; Minidoka, 174; and Paul, 606; (see fig. 1, index map).

The Union Pacific Railroad main line crosses the central part of Minidoka County from east to west; the Twin Falls and South Side branches cross the southern and southeastern parts of the county. U. S. Highway 30 traverses the southern part of the county, which has also a network of primary and secondary State and county roads. The northern part of the county is accessible by roads and trails. Many of the rural roads are passable by automobile only during dry or freezing weather.

The Minidoka North Side Project, which has been under gravity irrigation since 1907, occupies parts of Blaine and Minidoka Counties on the north side of the Snake River. The North Side Pumping Division is a tract of arable land adjacent on the north. It was formerly known as the North Side Extension and is so designated on the map (pl. 1). Since the map was drawn the official designation "North Side Pumping Division" has been adopted. The division, which comprises about 100,000 acres, was subdivided by the Bureau of Reclamation into three areas, designated A, B, and C. The areal subdivisions have been revised recently; Unit B of the present subdivisions includes all of former Area C and parts of A and B. The western part of Unit B is beyond the limits of the map. Unit B is of primary concern in this report; it is an elongated tract of about 66,600 acres that extends entirely across Minidoka County and includes some lands in southeastern Jerome County.

1/ Meinzer, O. E., The occurrence of ground water in the United States, with a discussion of principles: U. S. Geol. Survey Water-Supply Paper 489, pl. 31, 1923.

2/ Acequia precinct had a population of 806; population of Acequia village not separately listed in 1940 U. S. Census.

Previous Investigations

The Minidoka Irrigation District and the United States Bureau of Reclamation until recent years maintained systematic records of water levels in shallow wells in southern Minidoka County. Occasional investigations also were made by private engineers and consultants. Results of the earlier studies, however, were largely unavailable to the general public. Reports on the geology and ground-water resources of the Snake River Plain[1] were published by the United States Geological Survey in 1936 and 1938. These reports contained much useful information, including water-table contour maps of the Minidoka area and a description of the regional geology. The data in these reports have been useful for comparison with records and information obtained in the present investigation.

Purpose and Scope of Report

This report includes an outline of the general geologic features of the area, data on water levels in wells in Minidoka County and adjacent localities, the results of chemical analyses of representative water samples, and logs of wells and diamond-drill holes. A reconnaissance hydrologic map (plate 1) shows the locations of wells and test wells, and the contours of the water table and artesian-pressure surfaces.

Ground-water investigations have been in progress in Idaho since July 30, 1946, under a cooperative agreement between the United States Department of the Interior, Geological Survey, and the Idaho State Department of [redacted] Reclamation. Some of the information used in this report was obtained at various times in 1946 and 1947 as an incident to State-wide investigations; other data used are contained in the published reports of earlier investigations. Most of the information was obtained during a brief field period from October 30 to November 11, 1947, with the cooperation of field personnel of the Bureau of Reclamation. During that time a geologic reconnaissance was made, records of wells were obtained, water-level measurements were made, depths of wells were measured, elevations of wells were obtained by transit-stadia methods, and well drillers, irrigation district officials, and water users were interviewed. A few wells were selected for continued observation and periodic measurements of water levels have been made in these wells since October 1947 by the Geological Survey.

1/ Stearns, H. T., Crandall, Lynn, and Steward, W. G., Geology and water resources of the Snake River Plain in southeastern Idaho: U. S. Geol. Survey Water-Supply Paper 774, 268 pp., 31 pls., 16 figs., 1938; also. Records of wells on the Snake River Plain, southeastern Idaho: U. S. Geol. Survey Water-Supply Paper 775, 139 pp., 1936.

No significant exploration or development of ground water for irrigation was made within the Minidoka Project and adjacent areas north of the Snake River prior to 1947. Over a period of about 45 years a number of deep wells were drilled in and near the area as sources of stock, domestic, municipal, railroad, and military water supply, but these were tested and developed for only small or moderate amounts of water; the largest known production of water from any of these wells was about 350 gallons a minute. In the spring of 1947 three deep wells were drilled on properties of the Julion Clawson Farms, Inc., in the high plain area south of the Union Pacific Railroad between Kimama and Minidoka. During a 70-hour pumping test one of these wells produced about 3 second-feet of water (the capacity of the pump), with a negligible drawdown. The other two wells were not tested.

The feasibility of developing wells that will produce sufficient ground water to irrigate a part of the North Side Pumping Division is a matter of great public interest and importance. Ground-water development within the division would eliminate the construction of a long high-line canal to conduct water from Lake Walcott at Minidoka Dam, the construction of complicated lateral distributaries, the loss of large amounts of water by seepage from canals, and an initial pumping lift of about 100 feet to get water from the reservoir into the main high-line canal. The local development of ground water might result in great savings in construction costs to the government and to homesteaders, and might permit the opening of portions of the project for farm development earlier than would be possible otherwise. It would also release impounded surface water for use elsewhere. When the land is opened for settlement ground water would also be the source of stock and domestic water supplies.

R. J. Newell, Director, Region I, United States Bureau of Reclamation, requested the Division of Ground Water, United States Geological Survey, to make an investigation of the area in and adjacent to the North Side Pumping Division, to evaluate its ground-water resources, and to prepare recommendations for exploratory drilling and testing of wells. Field investigations disclosed very favorable prospects and sites for test wells were therefore selected. Contracts for test drilling were let by the Bureau of Reclamation late in January 1948. Drilling and test pumping were completed by April 1948. Further investigation is planned and additional wells probably will be drilled in 1949. A preliminary report for official use in connection with Bureau of Reclamation planning was prepared in April 1948. The present preliminary report is released pending preparation and publication of a more comprehensive report.

Personnel and Acknowledgments

Cooperative investigations of ground water in Idaho are conducted under the direction of A. N. Sayre, Geologist in Charge,

Division of Ground Water, United States Geological Survey, and Mark R. Kulp, State Reclamation Engineer, Idaho Department of Reclamation. During the detailed investigations upon which this report is based, the writer has had the benefit of consultation with personnel of the Regional and Central Snake River District offices of the Bureau of Reclamation. Leonard D. Jarrard, Geologist, Central Snake River District, assisted in the collection of field data in November 1947. Leveling of well elevations was done by Gerald L. Burwell, Engineer, Central Snake River District. Some chemical analyses of water samples were made by Vernon C. Bushnell, Soil Scientist, United States Bureau of Reclamation.

I am indebted to the Minidoka Irrigation District for copies of the logs of wells drilled during the early period of development of the Minidoka North Side Project. Jim Schoonover and Raymond R. Commons, well drillers, have contributed several well logs. Logs and other data on the Julion Clawson wells were obtained through the courtesy of Mr. Julion Clawson.

SOIL AND CLIMATE

The soils and climate of the entire Minidoka Project have been described in detail elsewhere[1]. A comprehensive detailed study of the soils of the North Side Pumping Division by the Bureau of Reclamation has recently been completed. In general the soils range in texture from sand to silty clay. They are derived from several sources; some materials have been transported long distances, and wind-blown deposits are an important component; loess is especially well represented in Unit B of the Pumping Division, and fine dune sand is prevalent in a wide belt between Kimama and Minidoka, north and south of the railroad. The various soils differ widely in permeability, water absorption, and susceptibility to underdrainage. Drainage problems in the county relate primarily, however, to topography and geology, rather than to soil character. In some small local areas soils of very low permeability have aided the development of swamps and alkali areas.

The climate of the area is semiarid, with a mean annual temperature of 48.2° F., and an average annual precipitation of 9.95 inches at Rupert. (See following table)

1/ Youngs, F. O., Baldwin, Mark, Kern, A. J., and McDale, G. R., Soil Survey of Minidoka area, Idaho: U. S. Dept. Agr., Bur. Chem. and Soils: Field operations of the Bureau of Soils, 1923, pp. 859-902, pls. 35-37, fig. 30, 1928.

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Annual precipitation, in inches, at stations in Minidoka Project, Idaho
(Records from U. S. Weather Bureau)

Year	Burley	Burley Airport	Burley Factory	Paul	Rupert	Year	Burley	Burley Airport	Burley Factory	Paul	Rupert
	Station						Station				
1907	-	-	-	-	19.62	1928	8.39	-	7.46	-	6.50
1908	-	-	-	-	10.79	1929	9.16	-	7.81	-	6.78
1909	-	-	-	-	16.97	1930	11.33	-	11.02	-	10.24
1910	-	-	-	-	16.86	1931	5.62	-	6.14	-	4.79
1911	-	-	-	-	11.87	1932	9.52	-	10.69	-	9.72
1912	-	-	-	-	15.50	1933	5.41	-	5.53	-	6.32
1913	-	-	-	-	12.18	1934	6.74	-	7.93	-	7.01
1914	-	-	-	-	12.18	1935	7.12	-	8.01	-	7.72
1915	-	-	-	-	10.76	1936	12.59	-	12.13	-	9.35
1916	-	-	-	-	-	1937	9.68	-	11.21	11.57	8.31
1917	-	-	-	-	10.83	1938	11.96	-	13.04	13.44	10.46
1918	7.80	-	-	-	8.65	1939	3.51	3.94	4.90	4.21	3.45
1919	8.65	-	-	-	7.18	1940	10.30	-	11.98	12.04	10.25
1920	9.42	-	-	-	10.00	1941	8.95	9.01	10.62	9.84	8.08
1921	14.28	-	-	-	11.55	1942	12.44	11.66	14.28	-	10.58
1922	11.71	-	-	-	11.85	1943	7.39	7.64	10.15	-	6.20
1923	15.04	-	-	-	13.45	1944	10.67	11.44	12.30	12.17	10.09
1924	7.16	-	-	-	7.44	1945	8.75	7.86	9.71	9.40	9.01
1925	11.26	-	-	12.93	11.70	1946	9.84	10.89	11.42	10.34	8.78
1926	6.05	-	5.01	15.82	7.69	1947	8.92	9.31	9.63	9.75	8.14
1927	11.26	-	12.37	-	12.31						

PHYSIOGRAPHY

The Central Snake River Plain is a part of the great Columbia Plateaus physiographic province as defined by Fenneman.1/ The plain is for the most part a large lava field, the surface features of which are determined largely by the source and extent of the lava sheets rather than by erosion. The Snake River and a few tributary streams, however, have incised their channels deeply into the plain; locally, alluvial flood-plain and lake-bottom terraces are developed in narrow belts of land adjacent to the main streams. Extinct volcanic cones and domes, from which the lavas of the Snake River Plain were extruded, remain as scattered buttes on the plain.

Within Minidoka County the Snake River Plain has all its characteristic features. The Snake River, at the southern boundary of the county, has not cut a deep canyon, as it has west of Milner, but occupies a restricted channel in which the water surface of the river is about 25 to 30 feet below the general level of the adjacent land area. North of the river there is a broad sedimentary stream terrace that forms a flat plain as much as 11 miles wide, narrowest at the southeast and southwest corners of the county and broadest at the middle. The north and central parts of the county, locally known as the bench lands, are an upland lava plain where the topography ranges from smooth to irregularly rolling and hummocky in places, with a few lava ridges, volcanic cones, knobs, and many small undrained depressions. The surface drainage pattern is incipient in the southern terrace area; in the bench lands a system of deep coulees and gullies is developed but the drainage pattern is not integrated.

There is a poorly defined low escarpment between the southern alluvial flats and the northern uplands. The North Side Pumping Division area is topographically transitional between the southern terrace area and the northern bench lands.

1/ Fenneman, N. M., Physiographic divisions of the United States, 3d ed: Assoc. Am. Geographers Annals, vol. 18, map, 1928.

GEOLOGY

General Features

The geologic formations that underlie the surface of Minidoka County were represented on plate 4 of the Stearns report[1] as Quaternary black basalt, Quaternary alluvium, Minidoka basalt, and undifferentiated Quaternary basalt. In the Minidoka Project the Quaternary alluvium is underlain by the Burley lake beds. A detailed restudy of the surface geology of Minidoka County has not been made and the classification used in the Stearns report is here retained.

Quaternary Black Basalt

Quaternary black basalt crops out only in a small area at the northeast corner of Minidoka County. This lava is at the southern limit of the Craters of the Moon lava field, which has been described elsewhere in considerable detail.[2] This lava has not been reexamined as it is hydrologically unimportant in Minidoka County. Stearns regarded the lava as of Recent age, possibly younger than the Quaternary alluvial deposits adjacent to the Snake River.

Quaternary Alluvium

The area in southern Minidoka County that is represented as Quaternary alluvium on plate 4 of the Stearns report includes, in addition to alluvium, residual soil and deposits of wind-blown material, with a few inliers of undifferentiated Quaternary basalt. The basalt occurs as ledges, knobs, and small irregular outcrops between Rupert and Minidoka, and west and east of Acequia. Loess and fine eolian sand are present as a superficial mantle over lava beds and older alluvium north and west of Acequia; they also cover large areas of central and northern Minidoka County and locally have a thickness of 30 or more feet (see logs of wells 7S 23E-25cc1, 26dd1, 8S 25E-1cb1). Fine dune sand is especially prominent in the area between Minidoka and Lake Walcott.

True alluvium is present in much of the area around Rupert and Paul and from there south to the river, though in some areas

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1/ Stearns, H. T., Crandall, Lynn, and Steward, Willard, Geology and water resources of the Snake River Plain in Idaho: U.S. Geol. Survey Water-Supply Paper 774, 268 pp., 31 pls., 16 figs., 1938.

2/ Stearns, H. T., Guide to the Craters of the Moon National Monument, Idaho, Caldwell, Idaho, Caxton Printers, 2d ed., 59 pp., 1936. Description also summarized in Water-Supply Paper 774, 94-100, 1938.

it contains a considerable admixture of loessial material. There are two distinct phases or ages of true alluvium, though these are separately mappable only in a generalized way. The older phase, consisting of silt, sand, coarse sand, and gravel, occurs beneath much of the Minidoka North Side area. At most places it is concealed by soil consisting of a mixture of its weathering products and wind-blown material. It is identifiable, however, in the logs of several wells (9S 24E-6da1, da2, 29ab1, ab2, ac1). The younger phase of the alluvium occurs chiefly along the channel of the Snake River, where it forms bars and beaches composed of silt, sand, and gravel.

All the alluvium is of Quaternary age. Gravels of the older phase occur on the north floor of Lake Walcott, between the Minidoka basalt and an underlying older porphyritic olivine basalt. Abundant paleontologic evidence proves the Pleistocene age of the older alluvium,1/ whereas the younger alluvium is Recent.

Minidoka Basalt

In a restricted area on the north side of Lake Walcott there is an outcrop of a pahoehoe flow to which the name Minidoka basalt was applied in the Stearns report (p. 83). It was found to be younger than the Pleistocene alluvial gravels of the terrace areas of the Minidoka Project. It is therefore also younger than the Burley lake beds. The source of the Minidoka basalt is believed to have been one or more of the volcanic cones near the town of Minidoka. Older lava below the Minidoka basalt appears to have issued from cones near the mouth of the Raft River Valley, to the southeast.2/

The Minidoka basalt and underlying basalt were not examined for the purposes of the present preliminary report. They are important, however, in connection with a study of the relations of Lake Walcott to the regional and local water tables, and future study is planned.

Undifferentiated Quaternary Basalt

It is noted in the Stearns report (p. 63) that throughout the Snake River Plain a large proportion of the lavas belong to the undifferentiated early Pleistocene basalt [redacted]. In general, in the area below Minidoka Dam, these are older than the flows that were named and individually described. The undifferentiated basalts are gray to black in color, rather fine-grained, and are vesicular at some places. Most of them are of the pahoehoe type, but aa lavas may

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1/ Stearns, et al., op. cit., pp. 91-93.

2/ Stearns, et al., op. cit., p. 83.

be present locally. Individual flows appear to be from 10 to 75 feet thick. Stearns et al. (p. 64) estimated that in the vicinity of Minidoka Dam the aggregate thickness of Pleistocene flows is about 600 feet. Beneath them there are probably older silicic lavas.

The undifferentiated Quaternary basalt may have erupted from a group of lava domes southwest and northeast of Kimama Station on the Union Pacific Railroad. Their relations to the Minidoka basalt and to older lavas beneath the Minidoka were not studied.

The undifferentiated basalts occur at or near the surface of most of northern, central, and western Minidoka County. There are also numerous small inliers within the area represented as Quaternary alluvium on plate 4 of the Stearns report.

Burley Lake Beds

The term Burley lake beds was proposed for a sequence of sediments, predominantly of lacustrine origin, that occur beneath the surface in Cassia and Minidoka Counties. The name has been accepted for use by the U. S. Geological Survey.1/ The Burley lake beds are mantled by loess, alluvium, and residual soil and have not been identified in surface outcrops. In the Stearns report (p.82) it is stated that they are represented by "150 feet of alluvium" logged in the City of Burley deep well (10S 23E-20dc4; see log, this report), and it was apparently intended that the term should apply to the beds between 8 and 158 feet below the surface and above the shallowest basalt. Generally similar beds were reported in the logs of deep wells near Paul (9S 23E-27bc1) and at Rupert (9S 24E-29ab1, ab2, ac1), but at those sites the thickness of beds above the first lava is less than at Burley. It is not known, however, that the "first lava" in each of these localities is a part of a single flow.

The Burley lake beds consist of clay, mud, silt, sand, and fine gravel. Some of the beds are well consolidated; others are soft and unstable and, when saturated with water, are highly mobile and troublesome during drilling operations.

Pre-Burley Volcanic ~~Rocks~~ and Sediments

Below the Burley lake beds there are similar clastic sediments and intercalated basaltic lavas to a known depth of more than 1,100 feet at Burley and more than 600 feet at Rupert. The total aggregate thickness is not known.

1/ Wilmarth, Grace M., Lexicon of geologic names of the United States, Part I; U. S. Geol. Survey Bull. 896, p. 299, 1938.

Sequence of Geologic Events

Stearns et al.[1] regarded all the undifferentiated basalts of the Minidoka region as early Pleistocene, and the Minidoka basalt as of somewhat later Pleistocene age. The Burley lake beds and the older phase of the Quaternary alluvium are older than the Minidoka basalt.

Basaltic flows earlier than the undifferentiated and Minidoka basalts appear in some instances to have originated from sources south of the Snake River. As these flows spread generally northward they may have shifted the course of the Snake River northward one or more times. The later undifferentiated flow, however, spread southward in Blaine and Minidoka Counties from northern sources, and shifted the channel of the Snake River permanently southward. Early in this sequence of events the Sand Springs basalt was extruded from sources between Kimama and Hazelton,[2] spreading westward and southwestward, spilling into the old Snake River Canyon and partly filling it from the northwest part of T. 7S., R. 13 E., for a distance of about 50 miles upstream, to the area south of Hazelton and Eden. Filling of the river channel effectively dammed the Snake River and the impounded waters spread widely over what is now the Minidoka Project. In the Stearns report this body of water is called Lake Burley, and in it the Burley lake beds accumulated to a maximum thickness of 90 to 150 feet. The areal distribution of these beds approximately coincides with the area of the Minidoka Project in Cassia and Minidoka Counties. At the boundaries of the lake the shore phases of the accumulating sediments overlapped or abutted on the surrounding lavas and other rocks. Northward and westward from Burley, Rupert, and Acequia, the Burley lake beds thin and disappear against basaltic rock masses of unknown thickness. Probably the older sediments beneath the Burley lake beds behave similarly. The lake remnant was then drained as the Snake River entrenched a new outlet through the basalt barrier on the west. As this entrenchment progressed upstream through the lake beds, the lake floor remained as a slightly elevated terrace adjacent to the river. Quaternary alluvium, loess, and residual soil were deposited as a mantle over the Burley lake beds and surrounding lava flows.

Summary of Geologic Data

North of the Minidoka North Side Pumping Division the residual and eolian soil mantle is more than 30 feet thick in places; beneath this is a succession of lava beds, some of which are separated by

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1/ Op. cit., p. 63.

2/ Stearns, et al., op. cit., pp. 80-82. The Sand Springs basalt does not crop out in Minidoka County and is not described in this report. It was extruded prior to deposition of the Burley lake beds.

well-weathered surfaces, and which occur to a known depth of 467 feet. Southward some of these flows terminate abruptly, probably having been truncated by the cutting of an old channel of Snake River as much as 7 miles north and west of its present channel. This old channel became partly filled with sediments, and later lava flows pushed the river southward. The Sand Springs basalt flow dammed the river west of Milner and impounded Lake Burley; 90 to 150 feet of lacustrine beds accumulated before the Snake River entrenched a new outlet sufficiently deep to drain the lake. After the draining of Lake Burley, the Snake River entrenched a new channel in the lake beds at or near the present channel site, while the old lake floor remained as a terrace. The Burley Lake beds and much of the lava were then covered by a mantle of Quaternary alluvium, loess, and residual soil.

WATER-BEARING PROPERTIES OF FORMATIONS

Quaternary Sediments

Coarse alluvial sands and gravels of Quaternary age occur at shallow depths beneath parts of the Minidoka Project. Their most extensive development is south of the Snake River in the Burley Irrigation District, Cassia County. They are well represented north of the river in the Minidoka Irrigation District, but are scantily developed in the area of the North Side Pumping Division. These Quaternary sands and gravels store and transmit moderate to large quantities of water. Wells from 31 to 105 feet deep in the city of Burley yield 375 to 1,000 gallons a minute with drawdowns of from 3 to 19 feet. At Rupert the 31-foot municipal stand-by well (9S 24E-29aa1) has a reported firm yield of about 275 gallons a minute.

Much of the shallow ground water in the project area is of local origin and is derived from percolation losses of irrigation water. This water is perched on impervious ~~Burley lake beds~~. The depth to the perched water table ranges from a few inches to about 18 feet, and subsoil drainage is an important problem in much of the irrigated area. South of the Snake River the subsoil drainage is accomplished with drainage ditches sunk below the water table, and by pumping from shallow wells. The drainage water is diverted into Snake River or is used as supplemental irrigation water.

In the North Side area all drainage is accomplished by ditches that discharge ground water into the Snake River, and into so-called sump wells. The sumps adequately illustrate the perched character of the shallow ground water. To construct the sump, a hole is dug or drilled through the shallow perched zone of saturation and the underlying impervious beds. Beneath ~~the latter an unsaturated~~ zone is encountered. Drilling is continued into the creviced or porous lavas above the regional water table. A bellmouth or other suitable intake structure is installed in the hole at the surface; screening and settling devices are installed to remove sediment and debris from the water, and drain ditches are then allowed to discharge into the sump well. The well leads the water to the unsaturated sub-surface zone, from which it drains off to the regional water table.

About 15 sump wells have been drilled in the North Side district, most of them in 1910 and 1912. The depths ranged from 65 to 137 feet. Some of these were unsuccessful as drainage wells and were abandoned because they did not encounter sufficient permeable [redacted] materials or open rock fractures to permit rapid intake of water. Some of the sump wells, however, are still in use. The drilled sumps become clogged rather readily and require occasional cleaning. A more effective type of drain is that at Goyne sump in the NW $\frac{1}{4}$ sec. 10, T. 9 S., R. 23 E. This pit was dug and blasted into lava to a depth of 90 feet, stopping above the regional water table. The intake capacity of the pit is said to be about 22 second-feet of water.

Burley Lake Beds and Older Rocks and Sediments

The Burley lake beds are not readily differentiated from the older pre-Burley beds in all well logs and, as the two do not crop out in the Minidoka Project, absolute distinctions between them as aquifers are not made in this report. The sediments of this sequence are an important source of water for deep wells in both the North and South Side areas. The water is under low artesian pressure but there are no flowing wells in the Minidoka Project. Water in the more shallow zones is cold and hard and under little pressure; water from successively deeper zones is progressively softer and warmer; in general, it is also under higher artesian pressure--that is, it will rise higher above the level at which it is struck, but the elevation to which water will rise decreases with increasing depth. The well of the Amalgamated Sugar Co. at its Rupert factory near Paul (9S 23E-27bc1) and the deep municipal wells at Rupert (9S 24E-29ab1) and Burley (10S 23E-20dc4) derive water from deep sources in the pre-Burley sediments and intercalated lavas. The log of the Burley municipal well (10S 23E-20dc4) illustrates the changes in artesian pressure with increasing depth. Only moderate yields are obtained from these wells. The water-bearing sediments are for the most part too fine to provide natural gravel pack, and artificial gravel packing of deep wells has not been practiced in this area. The wells commonly yield large quantities of fine sand when they are developed. Different well-construction and well-development methods would probably permit larger production from wells in the Burley lake beds and older sediments.

The most successful of the existing wells in these beds are cased throughout their depth and are perforated at the levels of the lava layers and coarser sands. The lava at the base of the Burley lake beds apparently contains water in moderate amounts, but some users report that this water is excessively hard.

Lava Beds

Massive solid lava is impervious and will neither yield nor transmit appreciable quantities of water. Massive lavas in some instances confine water under artesian pressure in underlying aquifers. Massive solid lava occurs in parts of the Minidoka Project and it is recorded in the logs of some wells.

Many lava beds, on the other hand, contain openings of several kinds, and these permit the storage and transmittal of ground water. Stearns et. al.1/ described the types of openings that store and

1/ Op. cit., pp. 58-63, 1938.

transmit water in lava. These are recapitulated in modified form as follows, in approximate increasing order of importance:

1. Tree molds, resulting from lava surrounding a tree and solidifying before the tree has burned away.

2. Vesicles and cavities occupied by expanded gases during the cooling of the lava.

3. Tunnels and cavities produced by liquid lava draining out from under a hardened crust (lava tubes).

4. Open tension joints formed by shrinkage of the basalt during cooling, or by differential movements of the crust of a hardening lava.

5. Interstitial openings formed during emplacement of cinders, aa, and subaqueous lava.

6. Large open spaces at the contact of a lava flow with an underlying formation or lava.

Tree molds are chiefly of academic interest and are of no hydrologic importance in the Minidoka Project.

The cavities in vesicular lava are of minor hydrologic importance. In some lava layers the openings are so numerous as to give the lava a spongy appearance. Well drillers commonly record these "spongy" lavas as sources of large volumes of water. Actually, massive vesicular lava can transmit but little water. The most "spongy" lava generally occurs at the top of an individual flow and is not itself the main source of water; the water comes largely from associated openings of type 6, at or near the contact between separate flows.

Lava tubes are of great importance in pahoehoe lava but available data are insufficient to indicate their extent in the Minidoka area. Underground cavities are reported in the logs of many wells, but none of these have been identified as lava tubes.

Open joint spaces formed by tension are common in lava beds; the vertical and lateral extent of individual joints may range up to some tens of feet. Shrinkage joints are extensively developed in several lava beds in the Minidoka area. Interconnections between systems of joints provide irregular channels of easy movement of ground water.

Some of the lavas interbedded with the sediments below the Burley lake beds may have cooled subaqueously, but none of the wells in the Minidoka North Side or North Side Pumping Division are known to have penetrated such lavas. Beds of cinders likewise have not been identified. Material reported as cinders in the logs of some wells, as the "red cinders" at a depth of 80 feet in well 9S 22E-33ab1 at the former Rupert Prisoner of War camp, probably are merely the red granulated or pulverized lava zones that commonly occur at the bases of lava flows. Thicker beds reported as cinders, as the "lava cinders" from 30 to 65 feet in the same well, may be granulated portions of an aa flow. The aa type of lava weathers readily when exposed at the surface or when acted on by subterranean water and gases. It therefore tends to lose its permeability with age, though when fresh it ranks among the most permeable of all rocks. Aa flows occur locally in Minidoka County but are less important within the depth explored than pahoehoe flows. Openings of type 5 are probably less important in the area studied than those of types 4 and 6.

Open spaces at or near the contacts of separate lava flows are among the most important of the water-bearing openings in the lavas of the Minidoka area. They are the type of opening most commonly encountered in drilling, though perhaps not as well known or understood by the well driller and layman as lava tubes, which are more impressive when encountered. The upper surfaces of lava flows and flow units are commonly somewhat brecciated, extensively fractured, and highly irregular in conformation. Subsequent flows tend to chill and solidify rapidly at their bases without filling in the surface openings. The flows and flow units tend also to become somewhat granular or brecciated, owing to rapid cooling, at the contact with earlier flows. These factors all tend to produce a highly porous and permeable zone at the contact between separate flows.

Definition of Terms

An aquifer is a water-bearing rock. The part of the rock which has its pore spaces completely filled with water is said to be in the zone of saturation. The water in the zone of saturation is called phreatic water. A water table is the upper surface of the zone of saturation in ordinary permeable soil or rock, except where that surface is formed by a confining impermeable body. In wells that penetrate ordinary saturated permeable materials the static water levels are about at the level of the water table, and for general purposes they define the levels of the water table at the well sites. Water that is held beneath a confining bed may be under sufficient hydrostatic pressure to rise in wells above the zone of saturation; it is then called artesian water. The source of the artesian pressure is the head of the water in the area where the aquifer is recharged. There is no absolute distinction between phreatic water and artesian water.

The piezometric surface of an aquifer is an imaginary surface that coincides with the static level of water in the aquifer. Contours of the piezometric surface are called isopiestic lines. The piezometric surface of water in an ordinary unconfined aquifer is generally the same as the water table and is called a normal-pressure surface. The piezometric surface of an artesian aquifer is called an artesian-pressure surface. The artesian-pressure surface is an imaginary surface that defines the elevations to which water will rise in wells that tap the artesian aquifer.

The depth to the water table is determined by the elevation and configuration of the land surface and of the water table. In general the water table in ordinary permeable material is high where the land surface is high, and low where the land surface is low; the relief of the water table is less than that of the land surface, however, so that the water table is a subdued and generalized replica of the overlying land surface. Thus, as a rule the depth to water is greatest where the land is highest. The depth to water or the artesian-pressure head can be measured where the aquifers have been penetrated by wells, test borings, or other openings. The general form of the piezometric surface can be represented on a map by isopiestic lines drawn on the pressure surface; the drawing of these lines is related to and controlled by available direct measurements of water levels in wells. The accuracy of the map depends upon the number, spacing, and accuracy of the measurements. The depth to the water table at any point is the difference between the land-surface elevation and the elevation of the isopiestic line beneath it. If land-surface contour lines are also drawn on the map, the depth to water at any location can be readily determined by inspection. The accompanying map (plate 1) represents the configuration and elevation of the piezometric surfaces in the area studied. The map is tentative except in the

Some of the wells have been destroyed; others have obstructions in them above the water level; only a few could be remeasured. The water-table contour map north of the railroad, as well as within the triangular area whose angles are at Kimama, Minidoka, and Acequia, cannot therefore be revised or improved until additional wells or test holes are drilled. Owing to the impossibility of making measurements in some of the wells in 1947, the 1928 and 1929 measurements necessarily have been used. The older measurements can not be adjusted to compensate for seasonal fluctuations and changes that may have occurred during the past 19 years, because continuous records for that period are not available. Such data as are available do not indicate that significant changes have occurred. The use of measurements widely separated in time, and made at differing seasons of the year may account for such anomalies as the low "dome" represented in the water table southeast of the center of T. 7 S., R. 23 E. A dome such as this would ordinarily represent a ground-water recharge area where rapid recharge and low permeability in the zone of saturation causes the ground water to pile up. Neither of these conditions prevails in the area of the dome; it is believed that such a feature does not actually exist.

The sharp valley in the water table, extending northwestward toward Kimama, if it is actually present, probably occurs in a zone of relatively high permeability in the lava. The irregularities represented in the vicinity of Paul and the former Rupert Prisoner of War camp west of Paul may be modified in detail with the aid of additional field data.

The water level measured in 1928 in well 6S 23E-32cd1, northwest of Kimama, is anomalous and was not used in the construction of the water-table contour maps of either this report or that of Stearns et al.

Plate 19 of the Stearns report indicates a pronounced trough in the water table, extending southwestward from the vicinity of Minidoka in the direction of Hazelton; the trough was believed to mark the position of a highly permeable buried former channel of the Snake River. The writer's interpretation of data collected in 1947 indicates that the trough postulated by Stearns is not present, and this interpretation was confirmed by the three test wells drilled in 1948. A less pronounced trough occurs about 6 miles south of that shown by Stearns. This may represent a buried river channel that enters Minidoka County north of Minidoka Dam, passes near Acequia, north of Rupert, and under Paul, and then trends about due west.

In Plate 19 of the Stearns report the contours on the perched water table in the vicinity of Rupert and Paul were drawn continuously with those on the regional water table to the north. The present map represents the form and position of the regional piezometric surface without reference to the local water table that is created by seepage losses from irrigation on the Minidoka Project.

vicinity of points of actual water-level measurements in 1947 and 1948. The hydrologic data are incomplete and the map will be revised when additional data are obtained.

Elevations of Piezometric Surfaces

On a water-table contour map elevations of the isopiestic lines and topographic contours must be related to a common fixed datum. The topographic contour map of the Minidoka Project by the U. S. Bureau of Reclamation is referred to a datum that is 49.52 feet below mean sea level.1/ The elevations of water levels and of the land surface at well sites, as given in the present report, are related to the Bureau of Reclamation datum; all elevations given in Table 1 are therefore 49.52 feet higher than they would be if referred to the datum of mean sea level.

Use of the Bureau of Reclamation datum does not affect the representation of the form of the water table or the computed depth to water at any given location. It does, however, affect the comparison of water-table elevations with the U. S. Geological Survey elevations of the water surface in the Snake River and in Lake Walcott; suitable adjustments must be made if comparison is desired. Direct comparisons likewise cannot be made with the water-table elevations given in Water-Supply Paper 775. At the time the field work for Water-Supply Papers 774 and 775 was done, Stearns et al. were handicapped by inadequate vertical control in the area. Moreover, some of the bench marks that were used as vertical control bases were related to a local datum rather than to mean sea level. An effort was made to adjust all elevations to a common mean sea-level datum. The elevations, nevertheless show a non-constant deviation from those in the present report.

Form and Position of Piezometric Surfaces

The water-bearing lavas in the Minidoka area are not uniformly permeable. For that reason the water table is less regular in form than it would be in uniformly permeable rocks. Some of these irregularities may be apparent rather than real. In most of the area the existing wells are too sparse to afford a sufficient number of direct measurements of the depth to water. Additional measurements might tend to smooth out some of the represented irregularities. In large areas, especially north of and adjacent to the Union Pacific Railroad between Kimama and Minidoka, many wells in which measurements were made in 1928 and 1929 cannot now be remeasured.

1/ See U. S. Geol. Survey Water-Supply Paper 983, p. 24, 1946: Datum of U. S. Geol. Survey staff gage in power house at Minidoka Dam "is 4,200.00 feet above datum of Bureau of Reclamation, which is 49.52 feet below mean sea level." The Bureau of Reclamation topographic map has not been published.

The local perched water probably descends by unsaturated flow to the regional water table along the north and west sides of the project where the Burley lake beds thin and disappear by overlap on the lava beds.

A permeable saturated formation that extends laterally from an unconfined zone to a confined zone beneath an impermeable bed, will contain phreatic water in the former zone and confined or artesian water in the latter (fig. 2). Along some line between the two the water table or normal-pressure surface will be continuous with and merge into an artesian-pressure surface; similarly, on a map the isopiestic lines of the one area will be continuous with those of the other area. The writer believes that the artesian-pressure surface in the vicinity of Rupert and Paul is continuous with a normal-pressure surface to the west, north, and east.

In the vicinity of Paul and Rupert the piezometric surface as described in this report does not conform to the strict definition of a single artesian-pressure surface. The term implies a single aquifer, the pressure in which produces the pressure surface. Two distinct aquifers would produce two distinct surfaces. Well and drilling records in the Minidoka Project, however, contain but little precise information on individual confined aquifers. The Rupert municipal well 9S 24E-29ab1, for example, taps water at 486 feet that rises nearly 400 feet, to an elevation of about 4,124 feet. The abandoned railroad well 29ac1, a few blocks distant and at about the same elevation, tapped water at 132 feet which reportedly rose about 80 feet to an elevation of about 4,155 feet, 31 feet higher than in the municipal well. The railroad well water level was not used for drawing the map because the reported depth to water could not be confirmed. Similar phenomena have been noted elsewhere, however, and obviously there are several or many confined aquifers; these are probably discontinuous, lenticular, to some degree interconnected through imperfectly confining beds, and variable in relative permeability and thickness. At present there is no hope of defining separate artesian aquifers or pressure surfaces. The surface as represented on the map, therefore, does not pertain to any single aquifer; it [redacted] represents the average of pressures in several aquifers.

The subsurface lavas of Minidoka County are not uniformly permeable. Individual branches of interconnecting systems of open joints and fractures extend to differing heights and depths. A well drilled at A (fig. 3) will encounter a free water table (WT) at a in an open joint that extends above the water table. A well drilled at B, on the other hand, will reach the level of the regional water table without encountering water, because the lava remains impermeable below that level. If the hole is deepened to reach the open saturated fracture at b, water will be encountered there and it will rise to a static level, c, at or near the level of the regional water table. The static water level in well B resembles an artesian-pressure surface, rather than a normal-pressure surface as in well A. These conditions are commonly encountered

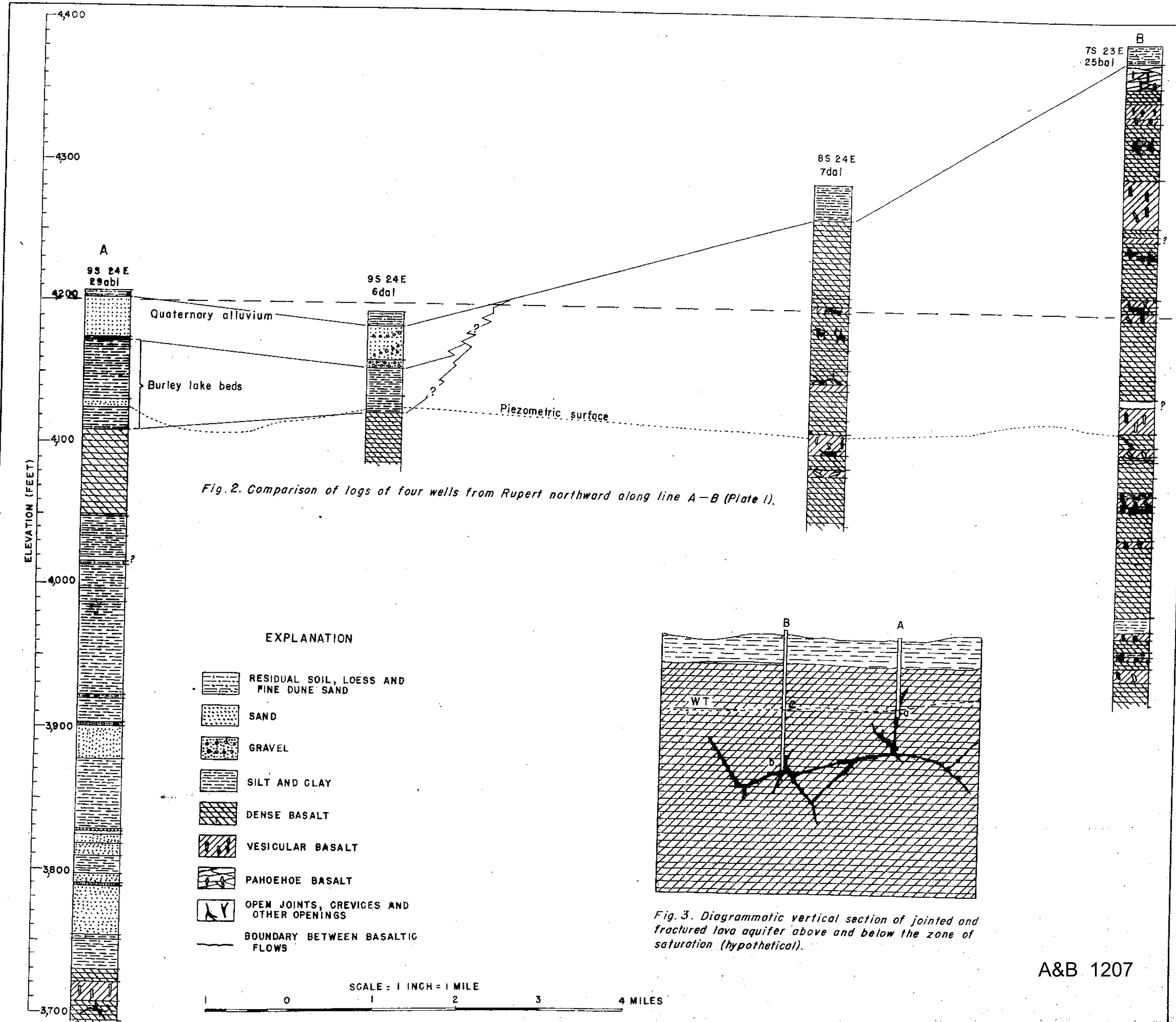

Fig. 2. Comparison of logs of four wells from Rupert northward along line A–B (Plate I).

Fig. 3. Diagrammatic vertical section of jointed and fractured lava aquifer above and below the zone of saturation (hypothetical).

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in parts of the lava plains. The amount of artesian rise of the water encountered in confined openings ranges from a few inches to as much as 25 feet. For purposes of drawing the water-table contour map these static levels have all been treated as points on a water table, since no other known procedure will represent the regional ground-water conditions with reasonable accuracy and simplicity. The facts, however, should be borne in mind when attempting to predict the depth at which water will be stuck in new wells. Prediction will be more accurate if it is phrased as a prognosis of static water level, rather than of depth to the zone of saturation.

Under much of the lava plains the lava aquifers are highly permeable at and well above the regional water table. Open cavities are commonly encountered by the drill above the zone of saturation. Most wells in the lava are of the "blowing and sucking" type. Air blows out of the wells when the external atmospheric pressure is lowering, and is sucked in when the outside pressure is rising. The air movement is often sufficiently rapid, to produce low rumbling noises and cause the ground to vibrate around the well. The intake and expulsion of large masses of air by these wells is conclusive proof that the lava underground is riddled with large openings above the zone of saturation.

It has been noted that at Paul and Rupert deep wells encounter artesian water in the Burley lake beds and older sediments, and in intercalated basalt layers. The tentative opinion is advanced that these beds have a general westward or southwestward dip and that ground water enters the pervious layers from the lava beds on the east and northeast, where the sediments interfinger with or abut against the lavas. At the edge of the sedimentary area, the water is under little or no artesian pressure. Westward and southwestward the pressure builds up and at Rupert it is sufficient to raise water from a depth of 500 feet to within 80 to 90 feet of the land surface. The inferred relations between the lavas and sediments are illustrated in the four columnar sections (fig. 2) along the line A-B of plate 1.

Movement of Ground Water

The highest observed elevation on the water table is in well 8S 25E-33ab1, near Minidoka, where it is about 4,153 feet. The water table is nearly as high in nearby wells, 8S 26E-4bb1, where the elevation is about 4,148 feet, and 8S 25E-1cc1, where it is about 4,146 feet. The ground water appears to move from the area of these wells radially southwestward and westward, with some northwestward components. Southeast of Minidoka there may be a depression in the water table with water moving into it from the north and west. Northwest of Minidoka, the apparent presence of two small troughs in the water table, in which the water moves northeastward, may merely be anomalies introduced by lack of recent water-level measurements in all wells. On the other hand, there may be local basins in the water table where ground water moves centripetally into depressions and is drained off to an unknown depth below. Northeast of Kimama there is a ridge in the water table entering the adjacent north parts of T. 7S., Rs. 23 and 24E., from the northern part of Minidoka County. The sharp trough in the water table that extends diagonally northwestward across the central part of T. 7S., R. 23 E., appears to mark a zone of exceptionally high permeability in the lava. The cascade in the water table in T. 9 S., R. 22 E., probably is controlled by a steep slope on the impermeable rock floor at the lower limit of the zone of saturation.

In general it may be said that some ground water moves into the northwest part of the Minidoka North Side Pumping Division from the north. Most of the ground water, however, appears to enter from an area on the east near Lake Walcott, in southern Blaine County. The Blaine County area is one of critical hydrologic importance and needs study. The area between the Snake River and the railroad also is an important one that requires study. In that area the artesian zone of saturation is well below the level of the Snake River. It is inferred that in at least a part of its course the river is perched or semiperched on impervious lake beds and channel deposits. The elevation of the artesian-pressure surface under these conditions would have no relation to the elevation of the water surface in the Snake River. On the other hand, the river may be in direct hydrologic connection with the perched water under the North Side Project. The average level of the water surface in the Snake River 1 mile below Minidoka Dam, at the U. S. Geological Survey gaging station, is about 4,137 feet above mean sea level, or 4,186 feet above the U. S. Bureau of Reclamation local datum. The average fall of the river in this area is about 2 feet per mile.

The rate of movement of the ground water in the Minidoka area has not been determined. Owing to the high permeability of some of the lava beds and the steep gradients of the water table, the rate of underflow probably is relatively rapid. In a comparable basalt area between Hazelton and Blue Lakes Spring, Stearns et al.[1] estimated that the rate of movement may be as much as 850 feet a day for the area as a whole. There is evidence that locally in the Snake River Plain ground water may move at more rapid rates.

Replenishment of Ground Water

There is no well-defined, integrated, natural surface-water drainage pattern in the area of the Minidoka North Side and North Side Pumping Division projects. Undrained depressions up to 40 acres or more in the area are common. Some of these are floored

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1/ U. S. Geol. Survey Water-Supply Paper 774, p. 62, 1938.

by silt and clay soil of low permeability and contain standing water for days after heavy rains or rapid melting of snow. Surface materials in most of the area, however, are sufficiently permeable readily to absorb and transmit water underground. Local runoff along ephemeral stream courses causes gullying on the steeper slopes, but the water is spread and dissipated in the flats and lowlands. Most of the local precipitation that is not evaporated at the surface or transpired by vegetation therefore percolates downward to perched and regional zones of saturation.

The perched water beneath the irrigated area is derived largely from percolation losses from irrigation. According to data published by Stearns et al.1/ In the whole Minidoka Project, both North and South sides, about one-third of the surface water applied for irrigation is lost to the zone of saturation.

The Snake River Plain is underlain by a body of ground water moving generally westward at a relatively rapid rate. Increments to this body of water from precipitation and irrigation are small locally but large in aggregate. In some areas, such as the Mud Lake region, and the Big and Little Lost River Valleys, large streams dwindle and disappear by underground losses, and these contribute large increments to the ground-water body. Storage reservoirs lose large amounts of water each year by seepage and deep percolation. All factors contribute to the storage and transmittal of immense quantities of ground water beneath the Snake River Plain. The amount of ground water that can be obtained locally therefore is not determined entirely by the local precipitation and replenishment, but also by the ability of aquifers to transmit water from the regional body of ground water to the local areas of withdrawal.

According to Stearns 2/ the successive lava flows that built up the Snake River plain forced the Snake River to shift its course from time to time. New channels were cut by the river as old ones were filled. The basaltic channel fillings, which have a general trend toward the west, tend to be more permeable than the main flow sheets, particularly along their contacts with older flows and river-channel deposits. Ground-water movement beneath the plain tends to be concentrated to some extent along the buried channels. The ground water beneath the North Side Pumping Division may be tributary to ground water in a buried river channel in southern Blaine and Minidoka Counties. If so it is favorably situated for replenishment with ground water from the east. In addition, percolation losses from the Minidoka Project are a local source of replenishment. Crandall has commented:3/

1/ Op cit., pp. 125-126.

2/ Op. cit., pp. 56-69, 135-147, pl. 25, fig. 10.

3/ Crandall, Lynn, Personal communication, July 20, 1948.

The Minidoka Project contributes over 200,000 acre-feet annually by percolation losses into this channel, equivalent to a flow of about 600 second-feet during a six months irrigation season. Losses from Lake Walcott and American Falls might be of the magnitude of 100 to 200 second-feet average during the summer months, making a total of 700 to 800 second-feet available supply from local sources. Whatever net development takes place in excess of this quantity must come from the general ground-water flow beneath the plains from upstream sources.

Samples of water from twelve wells, six surface drainage canals, and two locations in Lake Walcott were collected in 1947 and 1948 and were analyzed by Geological Survey and Bureau of Reclamation analysts. Several analyses of ground waters from the Minidoka Project and adjacent areas have been made by the Idaho State Chemist. A few analyses by consulting chemists for the Union Pacific Railroad Co. are also available. Table 1 includes the results of analyses of 22 samples of ground waters, 6 samples of surface drain-ditch waters, and 2 samples of Lake Walcott water. These analyses indicate only the chemical quality of the waters; they do not show their sanitary quality.

Dissolved solids in excess of 500 parts per million are objectionable in water for domestic and culinary use because they are apt to leave excessive precipitated residues in plumbing and cooking utensils, and are apt to be hard, requiring large amounts of soap. Concentrations of 1,000 parts per million or even more can be tolerated, however, if more suitable water is not available. The quantity of dissolved solids in the Minidoka ground waters ranges from 196 to 548 parts per million.

Hardness is an expression of the soap-consuming capacity of water. Water with a hardness of 50 parts per million or less is generally considered to be soft. If the hardness is between 50 and 150 parts per million the water is regarded as moderately hard; such water is satisfactory for most purposes but will deposit some scale in kettles, boilers, and hot-water pipes; soap consumption will not ordinarily be sufficient to warrant artificial softening for domestic use. Water having hardness of more than 150 parts per million is considered hard and the use of softeners may be warranted. The waters analyzed range from 118 to 191 parts per million in hardness.

The silica (SiO_2) content of most of the waters was not determined. Silica has no bearing on the suitability of water for irrigation.

The largest iron (Fe) concentration (1.0 part per million) was found in the Clawson irrigation well (7S 23E-26dd1). For industrial uses and public supply, iron in excess of 0.3 part per million is usually objectionable. Iron in excess of 1.0 part per million is generally undesirable as it tends to precipitate and stain some foods in cooking, and to discolor clothing, porcelain fixtures, and enamel ware.

Calcium (Ca) and magnesium (Mg) cause hardness and are the principal basic constituents in the waters in the area.

Ordinary concentrations of sodium (Na) and potassium (K) have little effect on water for most uses. In some of the analyses, sodium and potassium were not analyzed separately and the total combined amount is reported. In the Minidoka County samples the combined amount of sodium and potassium ranges from 12 to 46 parts per million. The amount of sodium in water for irrigation is of great importance because of the effect on certain types of soils. Sodium tends to deflocculate the clay particles in argillaceous soils, destroying the granular structure and making them impervious. Deflocculated soils will not drain properly even where they are well above the zone of saturation. Some of the soils in the Minidoka area could be injured by excessive sodium in irrigation water. Sodium in relation to other cations in the waters analyzed is small. Potassium has a similar effect but the amount present in natural waters generally is small even when sodium is high.

Carbonate (CO_3) is absent or insignificant in amount in most of the waters. Bicarbonate (HCO_3) is the principal anion in the waters analyzed.

Sulfate, chloride, fluoride, nitrate, and boron are minor constituents in the ground waters that were analyzed, and are probably of no importance in relation to use of the water for irrigation. Waters such as that from the Rupert city well approach the upper limit of permissible fluoride in water for domestic and public supply. None of the waters, however, contain injurious concentrations of fluoride.

The comparison of the analyses of surface and ground waters (table 2) was independently made by Vernon C. Bushnell to determine what chemical relation the surface water has to the well waters analyzed. The conclusion was reached[1] that, despite the general similarity in average composition of the surface and well waters, they are not closely related and do not have a common origin. This tends to confirm the writer's belief that there is no reason to expect that the surface and well waters involved in Bushnell's study would have any close chemical or genetic relation to each other. The well-water samples were not collected with such a comparison in view, and they include some that could not conceivably be genetically related to the surface drainage waters. The latter should more closely resemble the perched water in shallow wells in the vicinity of Paul and Rupert, which were not sampled. A chemical comparison of the impounded water in Lake Walcott with the water from deep wells, such as those at Minidoka and near Acequia, might yield more significant results.

1/ Memorandum from Vernon C. Bushnell, Soil Scientist, to Regional Planning Engineer, U. S. Bur. Reclamation, Region I, Dec. 4, 1947.

WATER ANALYSES

Table 1. Chemical analyses of waters from Minidoka County and adjacent areas.
(Well numbers, where given, correspond to those in Table 3, Records of Wells. Analyses from various sources. Parts per million)

Sheet 1 of 2

Well number, name or sample number	Date of collection	pH	Temperature (°F)	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Carbonate (CO_3)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Boron (B)	Dissolved Solids	Total hardness as $CaCO_3$
Ground Waters																		
UPRR Co. well Gooding (263 ft. deep)[a]	May 25, 1929	--	--	24	-	37	12	17		--	163	23	12	--	3.4	--	226	142
Gooding Municipal Wells[c] (Composite, 2 wells)	July 15, 1947	7.6	57	--	0.2	50	16	--	--	0	200	35	18	0.2	--	--	292	191
UPRR Co. well Jerome (326 feet deep)[a]	Sept. 5, 1926	--	--	25	Tr.	40	17	28		--	162	44	39	--	--	--	304	170
UPRR Owinza well[a]	May 25, 1929	--	--	22	Tr.	26	13	19		--	137	25	14	--	1.5	--	196	118
7S 23E-5cc1[a]	Mar. 18, 1930	--	--	30	--	32	17	21		--	149	46	17	--	1.0	--	241	150
do[c]	Nov. 10, 1947	8.1	54	--	--	35	15	11	0.6	0	79	30	7.4	--	--	0.08	---	
26dd1[c]	June 18, 1947	7.7	54	--	1.0	39	15	--	--	0	171	39	22	0.4	--	--	272	162
8S 22E-13cc1[d]	Nov. 10, 1947	7.2	53	--	--	59	21	19	4.3	0	131	47	22	--	--	0.04	---	---
8S 23E-27bd1[d]	Apr. 21, 1948	--	56	--	--	62	30	19	1.4	0	145	48	21.4	--	--	0.12	---	275
8S 24E-7da1[d]	Apr. 14, 1948	--	55	--	--	51	25	14	2.5	0	124	42.2	15.5	--	--	0.02	---	233
8S 24E-11ba1[d]	Apr. 4, 1948	--	55	--	--	47	21	11	1.7	0	100	42	12.2	--	--	0.10	---	205
8S 25E-1cb1[a]	Apr. 11, 1930	--	--	25	--	39	14	22		--	154	49	18	--	1.9	--	249	155
8S 25E-1cb3[d]	Nov. 10, 1947	7.7	53	--	--	44	14	8.2	1.2	0	66	38	8.3	--	--	0.08	---	---
do[b]	May 13, 1948	--	54	34	--	39	14	15		--	148	38	17	0.7	0.8	0.00	231	155
8S 25E-1cc1[c]	Oct. 17m 1946	7.3	54	--	0.06	38	14	--	--	0	163	34	17	0.6	--	--	252	153
29cc1[b]	May 13, 1948	--	58	41	--	54	17	45		--	242	48	36	--	4.5	0.01	365	204
9S 22E-23aa1[d]	Nov. 10, 1947	7.4	54	--	--	85	27	42	3.9	0	203	84	26	--	--	0.12	---	---

(Continued on next page)

(See footnotes at end of table)

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Table 1. Chemical analyses of waters from Minidoka County and adjacent areas--Continued

Sheet 2 of 2

Well number, name or sample number	Date of collection	pH	Temperature (°F)	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Carbonate (CO_3)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Boron (B)	Dissolved solids	Total hardness as $CaCO_3$
9S 23E-27bc1[d]	Nov. 10, 1947	7.7	63	--	--	37	11	18	2.8	0	116	6.2	9.1	---	--	0.12	---	---
9S 24E-1db1[d]	Nov. 10, 1947	7.7	52	--	--	65	18	11	1.8	0	116	44	16	--	--	0.12	---	---
1db2[b]	May 13, 1948	--	59	25	--	54	17	28		--	218	43	27	0.4	3.3	0.01	305	204
9S 24E-29ab1	Apr. 23, 1946	8.1	66	--	0.16	37	15	--	--	0	195	21	190	0.9	--	--	548	154
10S 23E-20dc4[c]	Jan. 26, 1945	--	71	--	0.02	33	11.4	--	--	0	144	21	40	0.3	--	--	282	129
Surface Waters																		
9S 23E-32bR1[de]	1947	5.8	--	--	--	83	34	24	10.2	0	170	16	19	--	--	0.08	---	---
9S 24E-27R1[df]	1947	7.7	--	--	--	74	22	12.4	3.7	0	144	47	11.5	--	--	0.08	---	---
9S 24E-31R1[dg]	1947	7.6	--	--	--	76	23	36.6	2.3	0	149	56	15.1	--	--	0.04	---	---
10S 23E-10R1[dh]	1947	7.7	--	--	--	72	32	14.6	5.1	0	171	64	17.5	--	--	0.04	---	---
10S 23E-14R1[di]	1947	7.8	--	--	--	69	42	28	6.3	0	189	93	21.3	--	--	0.08	---	---
10S 24E-3R1[dj]	1947	7.8	--	--	--	76	27	24	10.2	0	179	70	18	--	--	0.08	---	---
Walcott 1[bk]	May 13, 1948	--	51	15	--	44	17	26		--	180	48	25	1.2	0.4	0.01	265	180
Walcott 2[bl]	May 13, 1948	--	51	15	--	44	17	26		--	184	48	24	1.0	0.1	0.02	266	180

[a] Analyses as published in U. S. Geological Survey Water-Supply Paper 774, p. 175. Analyses by W. M. Barr, Consulting Chemist for U.P.R.R. Co., Omaha, Nebraska, and H. Harms, Utah State Chemist.
[b] Analyses by Vaughn Anderson, Senior Chemist, Idaho Dept. of Public Health.
[c] Analyses by R. T. Kiser, U. S. Geological Survey.
[d] Analyses by V. C. Bushnell, Soil Scientist, U. S. Bureau of Reclamation, Boise, Idaho. Converted from EPM to PPM by R. L. Nace.
[e] Sample from main drain, Minidoka Project, North Side at bridge at main highway, W. of N¼-corner, Sec. 32, T. 9 S., R. 23 E.
[f] Sample from main drain at bridge near NW corner, Sec. 27, T. 9 S., R. 24 E.
[g] Sample from main drain at main highway bridge near middle of Section 31, T. 9 S., R. 24 E.
[h] Sample from drain ditch at bridge near E¼-corner, section 10, T. 10 S., R. 23 E.
[i] Sample from drain ditch at bridge near N¼-corner, section 14, T. 10 S., R. 23 E.
[j] Sample from drain ditch near NW corner, section 3, T. 10 S., R. 24 E.
[k] Lake Walcott at Minidoka Dam, 1,200 feet south of north abutment, 6 feet below water surface.
[l] Lake Walcott at Minidoka Dam, 2,000 feet south of north abutment, 6 feet below water surface.

Table 2. Comparison of averages of analyses of surface and ground waters of

Minidoka Project Area

(Analyses and table by V. C. Bushnell, Soil Scientist, U. S. Bureau of Reclamation. Originally reported in equivalents per million; recalculated to ppm by R. L. Nace.)

	Conductivity (Micromhos at 25° C)	pH	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Carbonate (CO_3)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Boron (B)
Surface waters (6 samples)	670	7.42	75.	31.	24.	5.7	0.0	167.	58.	17.	0.07
Ground waters (6 samples)	493	7.49	54.	18.	18.	2.5	0.0	119.	42	15.	0.09
Ratio: $\frac{\text{Surface}}{\text{Ground}}$	1.36	--	1.39	1.75	1.34	2.23	---	1.41	1.38	1.15	0.78

POSSIBILITIES OF FUTURE DEVELOPMENT OF THE
GROUND-WATER RESERVOIR

Maximum development of a ground-water reservoir requires the fullest possible economic utilization of increments of water to the reservoir. This involves the salvage of natural losses from the underground reservoir through springs, seeps, and ground-water underflow. The Snake River Plain is a large ground-water province, diverse as to detail, but with some salient features that are ubiquitous. North of the Snake River, from northeastern Idaho westward to the vicinity of King Hill, there is a general mass movement of ground water toward the west and southwest. Throughout the plain, part of the local precipitation enters the ground and reaches the zone of saturation. Stearns et al. 1/ postulated that a large part of the ground water moving beneath the western part of the Snake River Plain enters the zone of saturation beneath the valleys of the Big Lost and Little Lost River, the Snake River, and other streams, and beneath the Mud Lake area. Westward, in the vicinity of Hagerman and elsewhere, not only are the water-bearing lavas cut through by present and former channels of Snake River, but the underground movement of water farther westward is blocked by deposits of impermeable lake beds. Most or all of the annual ground-water increment from a large part of the Snake River Plain is believed to be discharged in the springs and seeps between Milner and King Hill, especially in the Hagerman Valley.

The groups of springs known as Thousand Springs, Snowbank Springs, and Sand Bank Springs discharge an average of 600 to 700 second-feet of water. 2/ The Malad Springs in 1924 discharged 1,149 to 1,190 second-feet. 3/ Other springs and groups of springs have measured discharges of from a few to several hundred second-feet. The total of the measured spring discharges into the Snake River between Milner and King Hill is about 5,000 second-feet. 4/ This amount does not include direct return seepage from irrigation, the contributions of drainage ditches, or the discharges of many small springs and dispersed seeps. The aggregate of measured and unmeasured average additions to the Snake River from the north side probably approaches 6,000 second-feet. The following tabular summary of the average inflow into the Snake River from all sources between Milner and King Hill, in second-feet, during a 37-year period, is based on United States Geological Survey records from gaging stations at Milner and King Hill:

1/ Stearns, et al., op. cit., pp. 108-116.

2/ Hoyt, W.G., Water utilization in the Snake River Basin: U. S. Geol. Survey Water Supply Paper 657, p. 205, 1935.

3/ Stearns, et al., op. cit., p. 166.

4/ Stearns, et al., op. cit., pp. 143, 198-201.

1911	5,850	1923	7,230	1935	6,848
1912	6,100	1924	7,010	1936	7,489
1913	6,380	1925	7,230	1937	7,381
1914	6,480	1926	7,100	1938	7,636
1915	6,320	1927	7,420	1939	7,813
1916	6,500	1928	7,500	1940	7,486
1917	6,900	1929	7,550	1941	7,527
1918	7,200	1930	7,470	1942	7,957
1919	7,390	1931	7,190	1943	8,517
1920	6,740	1932	7,308	1944	7,917
1921	7,400	1933	7,516	1945	8,045
1922	7,370	1934	7,228	1946	8,301
				1947	8,164

According to Hoyt[1] the average inflow for the 10-year period from 1921 to 1930 was 7,330 second-feet, or 5,307,000 acre-feet a year. Probably 1,500 second-feet of this amount is derived from irrigation return flow and tributary streams on the south side of the Snake River.

The measurements and estimates published by Stearns and Hoyt both indicate that the gains of the Snake River from the north side between Milner and King Hill amount to nearly 6,000 second-feet. Hoyt has also estimated that of the total average inflow from both the north and south sides of the river, approximately 7 percent occurs between Milner and Twin Falls, 5 percent between Twin Falls and Perrine Bridge, 61 percent between Blue Lakes and Upper Salmon Falls, and 27 percent between Upper Salmon Falls and King Hill.

The amount of ground-water recharge to the aquifers in Minidoka County alone cannot be directly measured or estimated, as the area is part of the Snake River Plain ground-water province. The entire province must be considered as a unit in which the sources of recharge are many and varied. So long as the amount of water in underground storage remains constant, it is obvious that recharge from all sources must balance the total discharge of ground water by all processes, natural and artificial. Information is not available on the total artificial discharge from the ground-water reservoir of the Snake River Plain north of the Snake River. The amount of present withdrawals through stock, domestic, irrigation, municipal, and railroad supply wells is very small in proportion to the total amount that is perennially available and is discharged naturally by ground-water overflow from springs and seeps along the Snake River.

Records of water levels in wells in Minidoka County and adjacent areas do not indicate that there has been any significant change in the amount of water in underground storage in the past 20 years. There have been no observed material net changes in water levels in Minidoka County since 1928. Locally the water table may have risen a few feet in some places and fallen in others. The following table summarizes the known net changes in water levels in wells in the area concerned.

1/ Op. cit., p. 229.

Comparison of water levels in wells, in feet below land-surface datum, 1928 and 1947

Well number	Date	Depth to water (feet)	Net change
6S 23E-26cc1	June 14, 1928	354.7	
	Nov. 4, 1947	360.6	- 5.9
31da1	June 20, 1928	294.9	
	Nov. 4, 1947	290.7	+ 4.2
7S 23E-25cc1	June 9, 1947	260.3	
	June 10, 1947	259.2	
	June 24, 1947	258.5	+ 1.8
7S 25E-9dc1	June 14, 1928	227.4	
	Nov. 8, 1947	222.0	+ 5.4
15dc1	June 14, 1928	263.1	
	Nov. 8, 1947	262.7	+ 0.4
8S 22E-13cc1	Nov. 15, 1928	315.0	
	Oct. 30, 1947	322.4	- 7.4
8S 23E-16da1	July 7, 1928	190.6	
	Oct. 30, 1947	187.9	+ 2.7
8S 25E-33ab1	Mar. 29, 1927	88.0	
	May 18, 1927	83.0	
	July 16, 1927	80.0	
	Sept. 6, 1927	77.6	
	Oct. 14, 1927	78.8	
	Oct. 31, 1947	74.4	+13.6[a]
9S 24E-1dc1	Mar. 30, 1927	64.5	
	May 19, 1927	65.0	
	May 24, 1927	65.4	
	July 7, 1927	61.7	
	Sept. 7, 1927	62.3	
	Oct. 17, 1927	61.1	+ 3.4

[a]This is the only well in the area in which water-level measurements are available for 1927 and 1947 in the same month of the year. Note that the seasonal fluctuation is at least 9.2 feet and that the net change, October to October, is actually only + 4.4 ft.

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The inadequacy of available water-level records effectively illustrates the need for a network of observation wells in the area. Continuous water-level records for a period of time will establish the seasonal and other fluctuations of the water table and will indicate the net changes from year to year.

Because the principal sources of water in the zone of saturation, particularly in lava beds, beneath the Minidoka Project are regional rather than local, the amount of ground water available for the North Side Pumping Division area is very large. The only heavily pumped wells near the area are those of the Julion Clawson Farms, which were first placed in production in the 1948 irrigation season. It is estimated that Unit B of the proposed project will require about 1,030 second-feet of water for irrigation continuously during a 120-day irrigation season. This is about 17 percent of the excess of ground water that is continuously lost from underground storage by overflow from the ground-water reservoir between Milner and King Hill. The ground water pumped for irrigation thus would not constitute a drain on permanent reserve storage, but would be salvage of water that would otherwise be discharged by seeps and springs.

It is understood that current developments on the Julion Clawson Farms, Inc., north of the central part of Unit B, are directed toward the ultimate development of sufficient ground water to irrigate 18,000 acres of private land. Assuming the standard figure of 3.5 acre-feet of water per acre, plus 5 percent for canal loss of water, the Clawson development will use 66,150 acre-feet of water during the pumping season, or a continuous discharge of 277 second-feet. Other small private developments will require a few more second-feet of ground water.

If the U. S. Bureau of Reclamation and private projects are completely developed, the ultimate withdrawal of ground water in the North Side Pumping Division and adjacent areas will be about 1,320 second-feet within an area of about 85,000 acres. The rate of withdrawal for the entire area will amount to about 22 percent of the average total rate of discharge of the springs along the north side of the Snake River Canyon between Milner and King Hill.

Most of the proposed development area is underlain by permeable, well-drained soils. Much of the water spread for irrigation [redacted] will return to the zone of saturation. The consumptive use of water therefore will be considerably less than the estimated requirement of 1,030 second-feet for the Pumping Division. To the extent that it represents salvage from natural discharge the water that is consumed will reduce the flow of seeps and springs. Some springs probably will be affected more than others. If the geology and movement of ground water between Rupert and the segment of the Snake River between Milner and King Hill are as described in the Stearns report, the greatest effect probably will be at springs from Devil's Corral to Clear Lakes, with lesser effects from Clear Lakes to Hagerman.

The principal question with respect to the development of the required large supply of ground water in a relatively small area relates to the ability of the aquifers to transmit water from the regional to the local zone of saturation. The drawdown in existing wells that have been pumped at moderate to high rates is very small. The known and estimated rates of underflow are moderate to high. The rate at which water can be transmitted to wells in the area is high. Private engineers have estimated, for example, that the Clawson well (7S 23E-26dd1) is capable of supplying the largest extant deep-well pumps. Caution is advisable, however, in considering such estimates, because of the nature of the lava aquifers. In many highly permeable aquifers, such as coarse river gravels, increasing the pumping rate and drawdown will increase the yield roughly in proportion to the square root of the drawdown. Assuming constant thickness of the zone of saturation in the lava aquifers, and turbulent flow of water in the crevices, increasing the pumping rate and the drawdown may increase the yield in about the same ratio as with gravel aquifers. If the crevices become partly dewatered, or if the water level in the well is drawn down below the openings, the increase of the yield in proportion to the drawdown may be in either a smaller or larger ratio. Therefore the usual methods of calculating specific capacity, and estimates of potential yields based on pumpage and drawdown tests, cannot be applied indiscriminately to wells in lava aquifers. If the water-bearing lava is aa, talus breccia, or similar rock with mass permeability, calculations and estimates apply in general in much the same fashion as with river gravels and similar deposits.

The water-table contour map (pl. 1) was first drawn from data compiled before the three Bureau of Reclamation test wells were drilled in Unit B. The map was used to select favorable test sites and to predict the static water levels in wells. The actual and predicted depths to water in the three wells are as follows:

Well number	Predicted depth to water	Measured depth to water
8S 23E-27bd1	186 feet	179 feet
8S 24E- 7da1	160 feet	168 feet
-11ba1	167 feet	166 feet

The seasonal fluctuations of the water table in the area are not known. The points of control measurements on which the water-table contours in Unit B were originally drawn were from 8 to 12 miles apart. Considering these factors, the water-table contour map was remarkably reliable; the new water-level data afforded by the test wells has permitted some refinement of the map details, and the necessary minor alterations of the original map have been incorporated in plate 1. The test-well data disprove the existence of a pronounced trough in the water table beneath the Pumping Division area.

The three test wells were test pumped during April 1948. Discharge measurements were made by Charles LeMoyne, Jr., Engineer,

Central Snake River District, Bureau of Reclamation, with a manometer gage on the discharge pipes; the water was discharged through a sharp-edged circular orifice of precisely-known size. The orifice and manometer were initially calibrated against a 6-foot Cipolletti weir to determine their accuracy, and were found to measure the discharge correctly within a 5-percent limit of error. The test-pumping periods were 72 hours in length. Water levels in the wells were measured by air line and pressure gage. The results of the pumping test are shown in the following table.

Well number	8S 23E 27bd1	8S 24E 7da1	8S 24E 11ba1
Dates of test (1948)	Apr. 18-21	Apr. 11-14	Apr. 1-4
Static depth to water before beginning of test (feet below land surface)	178	168	165
Discharge rate (gallons a minute)	2,050	2,150	2,120
Maximum drawdown (feet)	18	1.1	3
Time required for stabilization of pumping level (minutes)	10	30	10
Water temperature (degrees Fahr.)	56	55	55
Appearance of water	Clear	Clear	Turbid during 1st hour and for 30 min. on 2d day.

The pumping tests demonstrated that ordinary wells in the area can be pumped in excess of 4.5 cubic feet per second with small or negligible drawdowns. The conclusion is drawn that properly constructed and favorably situated wells tapping the lava aquifers are capable of supplying the largest economical pumping units that are likely to be installed. Yields of at least 6 second-feet may be expected from individual wells with drawdowns far within the maximum limits of economic pumping lifts. Whether or not pumping units with capacities exceeding 6 second-feet should be used is an engineering problem and should be solved for individual wells with due regard to construction and equipment costs, and the locations of the wells with respect to their service areas. Additional pumping tests at higher discharge rates are needed to obtain more complete drawdown data.

The extent of the areas of influence of heavily pumped wells in the Pumping Division remains to be determined. In June 1946, measurements were made on the Clawson well, 7S 23E-25ccl, at the start of a pumping test on well 26ddl. The two wells are about a quarter of a mile apart. After well 26ddl had been pumped for 36 hours at a rate of 3 cubic feet per second, there was no lowering of the static water level in well 25ccl; on the contrary, the static level rose about 1 foot. Many wells are highly sensitive to changes in atmospheric pressure and their water levels rise and fall in response to such changes. The change in static water level in well 25ccl during the pumping test was probably a barometric effect completely unrelated to any effects of pumping well 26ddl. It is inferred that the area of influence of individual wells in permeable lava in this locality is small and that appreciable influence from well 26ddl did not extend as far as well 26ccl.

Ground-water conditions in the part of Unit B that extends westward into southeastern Jerome County were not studied in the field because the development of ground water for irrigation in that area was not anticipated in 1947. The depth to the zone of saturation in the Jerome County part of Unit B is appreciably greater than it is in the western part of former Area C. Static water levels as much as 311 feet below the land surface have been measured in sec. 4, T. 10 S., R. 21 E. The average westward slope of the water table for 10 miles west of the Rupert Prisoner of War Camp area is about 10 feet per mile. Therefore, at the western edge of Unit B the elevation of the water table is about 3,920 feet; the depths to water at different sites may range from 250 to 300 feet.

A continuous discharge of 1030 second-feet of water for 120 days would supply about 3.5 acre-feet of water per acre to 66,600 acres of land, plus 5 percent loss of water in canals. An average discharge of 3.5 second-feet from 294 wells, or of 6 second-feet from 171 wells, would supply the required amount of water. The actual number and discharge rates of wells probably will be intermediate between the two extremes. Assuming 230 wells discharging 4.5 second-feet each, there would be an average of one well for each 290 acres of land, or 2.2 wells per section. This spacing is not too close for an area of highly permeable aquifers, a thick zone of saturation, and a large source of replenishment.

Wells in the Pumping Division area will have to be sited on high ground within their respective distribution areas and their spacing therefore will be somewhat irregular. Within most of former Area C the water table slopes rather uniformly westward. In the southwestern part of Unit B the slopes are steeper and less uniform in direction. Heavy pumping will alter the configuration of the water table. In general, as the number of wells increase, wells at the up-gradient edges of the area will be the most favorably situated to receive rapid recharge. Probably the wells will be grouped more closely toward the north and east than toward the south and west.

The development of from 600 to 800 second-feet of ground water in the Pumping Division area is a safe initial minimum goal because approximately that amount of water is available from ground-water recharge from local sources. The additional quantity of water that can be withdrawn perennially cannot be determined in advance. Development should therefore proceed slowly. After the development of 600 second-feet, further development should be in increments of 200 or 300 second-feet. During all stages of development careful records should be kept of static water levels in wells, drawdowns, discharge rates, and water levels in observation wells.

Plans of the Bureau of Reclamation include the drilling of seven additional production wells in Unit B in fiscal 1950 and pumping six to ten wells for irrigation. The purpose of the plan is to test further the inferred ground-water conditions and to determine the local effects on the water table of heavy pumping. In order to accomplish these objectives it is recommended:

(1) That three of the new wells be grouped around one of the existing wells within a $\frac{1}{2}$ to 1 mile radius.

(2) That the remaining four wells be so sited as to test further the elevation and configuration of the water table

and to determine whether or not the Burley lake beds or older sediments extend northward into Unit B. The latter possibility is unlikely, but the facts should be determined definitely as the presence of fine-grained sedimentary aquifers will materially affect the yield and type of construction of wells. Recommended sites for these four wells are as follows:

a. Sec. 8, T. 8 S., R. 23 E.
b. Sec. 28, T. 8 S., R. 24 E.
c. Sec. 5, T. 9 S., R. 23 E.
d. North-central part of T. 9 S., R. 21 E.

The more specific locations are hydrologically immaterial and can be related to the local topography and service areas of the wells.

(3) That four wells, 6 or 8 inches in diameter, be drilled in andnear Unit B as permanent observation wells. Recommended approximate locations for observation wells are as follows:

a. North part of sec. 2, T. 8 S., R. 23 E.
b. Southeast part of sec. 31, T. 8 S., R. 24 E.
c. Central part of sec. 24, T. 8 S., R. 25 E.
d. West part of sec. 6, T. 9 S., R. 21 E.

(4) That well 9S 22E-33ad1 be set aside as a permanent Federal observation well.

(5) That permanent ownership of and right of entry to observation wells be vested in the Government.

The three existing test wells were drilled with an approximate diameter of 20 inches with 20-inch casing. It is recommended that these wells be test pumped at rates of 6 or 7 cubic feet per second. Additional observations of yields and drawdowns will provide a better basis for engineering determinations of the most economical and desirable sizes of pumping units and casing. If firm yields of more than 3 second-feet can be obtained this will permit a substantial reduction in the number of wells necessary to supply the entire area and may materially reduce the construction and equipment costs.

In general, because of the known occurrence of large amounts of water in the permeable lavas of Unit B, the drilling of small test holes is neither necessary nor desirable. Pumping tests on small wells will not necessarily indicate the probable yields of large production wells at the same sites because of the nature of the aquifers and the manner of transmission of water through lavas (see page 35). If wells along the southern boundary of the area encounter sedimentary aquifers, however, it may be advisable to sink small test wells to determine the depths and thicknesses of the most permeable zones and to forecast the size and amount of casing required.

Lake Walcott, impounded by Minidoka Dam, loses large amounts of water annually by seepage. Concerning these losses Stearns et al.[1] have commented:

> It thus appears that the seepage losses from Lake Walcott in the first 52 months of its existence were 1,392,000 acre-feet greater than the seepage losses for a like period in more recent years. Although this figure is only roughly approximate, because of the incomplete character of the records for a part of the period, it indicates that a very great amount of water went into permanent ground-water storage in the lava beds adjacent to Lake Walcott during the early years of its existence.
>
> Evidence of this ground storage is afforded also by the testimony of Liberty Hunter, a rancher living on the Lake Channel, an ancient abandoned spring alcove several miles north of Lake Walcott. He reports that the ground water in the vicinity of his place began to rise about 18 months after the construction of Lake Walcott and began to appear in sloughs in the bottom of the Lake Channel in about 1909 at points as far as 5 miles from the shores of Lake Walcott.

The facts stated above do not eliminate the possibility that some of the reduction of seepage losses from Lake Walcott may have resulted from silting up of the lake bottom and natural sealing of orifices. It is also noted that, as shown on plate 19 of the Stearns report, the Lake Channel is actually east of the main body of Lake Walcott. Some of the increased permanent ground-water storage may result from seepage losses from the American Falls Reservoir, northeast of the Lake Channel. According to Mr. Grandall[2] the American Falls Reservoir also loses appreciable amounts of water by seepage; there is evidence that since the construction of American Falls dam, spring discharges have increased and the water table has risen in the Lake Channel area, with consequent gains to the Snake River from effluent ground water between Neeley and Minidoka. The river discharge in that area is large, however, and losses and gains between American Falls Reservoir and Lake Walcott are difficult or impossible to measure because the amounts involved are within the percentage limits of error of standard stream-gaging methods.

Ground water from the area west of American Falls Reservoir moves southwestward to the Lake Channel area; from there it probably moves westward past the north side of Lake Walcott. Some

1/ U. S. Geol. Survey Water-Supply Paper 774, p. 197, 1938.
2/ Personal communication, April 22, 1948.

observers infer that heavy ground-water withdrawal in the North Side Pumping Division will lower the water table near Lake Walcott and cause increased seepage losses from storage in the lake. If the lake water is not continuous with the zone of saturation, a lowered water table will have no affect on seepage losses. If the lake is continuous with the zone of saturation, heavy pumpage may or may not materially affect seepage losses, depending on the directions and gradients of ground-water flow. The relations of Lake Walcott to the water table should be carefully studied. There are no deep wells near the lake. Exploratory holes should be drilled around the lake to establish the relations of the lake to the water table.

Measurements and study of the perched ground water beneath the Minidoka North Side area were not made for the present report. Data in the Stearns report indicate that a large amount of perched ground water in the area moves northward and westward and becomes an increment to the regional zone of saturation in the lavas of the North Side Pumping Division. To the extent that this occurs, pumped water in this area will be salvage from irrigation seepage loss and will not constitute a withdrawal of water that, under natural conditions, would be discharged in springs between Milner and King Hill. A quantitative study should be made of the regional ground-water increment from the perched ground water of the North Side area. The results of such a study will have a material bearing on questions concerning the discharge of large springs along the Snake River and the rights of electrical-power and other interests that depend on those springs.

The total average discharge of springs along the Snake River between Milner and King Hill increased materially during the 18 years from 1902 to 1919, and became stabilized about 1919.[1] The increase was a direct result of ground-water recharge from percolation losses of water on Bureau of Reclamation and other irrigation projects. These facts have an important bearing on downstream water rights and the effects on spring discharges of heavy withdrawals of ground water in the Minidoka Project.

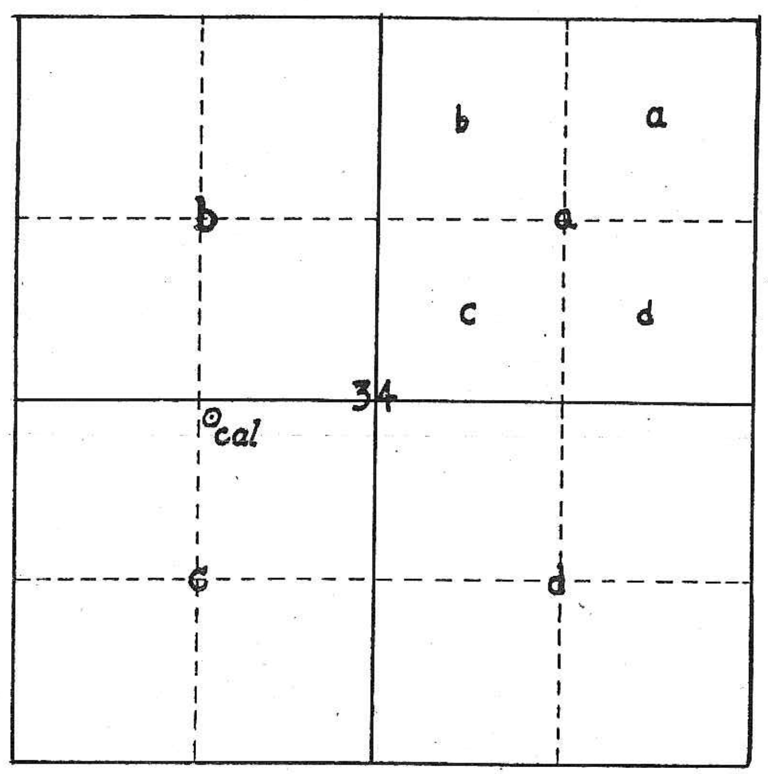
Regular measurements should be made of the discharge of representative springs along the Snake River between Milner and King Hill. These measurements, in conjunction with records of ground-water levels in observation wells, would materially assist the determination of the relations between spring-discharge fluctuations and upstream development of ground water on irrigation projects. The records of ground-water levels and spring discharges will be essential for making periodic estimates of the quantities of ground-water that may be withdrawn safely on the North Side Pumping Division.

A reconnaissance of the spring area will be made in 1948 by the Geological Survey, in cooperation with the Bureau of Reclamation,

1/ Meinzer, O.E., Large springs in the United States; U. S. Geol. Survey Water-Supply Paper 557, pp. 43-50, 1927; Stearns, et al., op. cit., pp. 124-136, 142-143, 154-166; Hoyt, op. cit., pp. 227-229.

for the purposes of selecting locations for gaging stations, and of enlarging the net of existing observation wells. It is hoped that the gaging program can be started by the Geological Survey in the 1950 fiscal year.

Idaho well numbers indicate the locations of wells within the official rectangular subdivisions of the public lands, with reference to the Boise base line and meridian. The first two segments of a number designate the township and range. The third segment gives the section number, followed by two letters and a numeral, which indicate the quarter-section, 40-acre tract, and serial number of the well within the tract. Quarter-sections are lettered a, b, c, and d in counterclockwise order from the northeast quarter of each section, as in the adjacent diagram. Within quarter-sections the 40-acre tracts are lettered in the same manner. Well 7S 2E-34cal is in the $NE\frac{1}{4}$ of the $SW\frac{1}{4}$ of sec. 34, T. 7 S., R. 2 E. Where wells are very closely spaced the 40-acre tracts may be subdivided into lettered 10-acre tracts, and well numbers will contain a third letter, as 34cabl.



Wells

7S 23E-5ccl. Union Pacific Railroad Co. Kimama Well. Log from record by company water-service foreman at time well was drilled, obtained by U. S. Geological Survey, 1928. Not previously published or released. Terminology slightly modified, 1947.

Material	Thickness (Feet)	Depth (Feet)
Clay [loess]	9	9
Lava, very hard, gray	81	90
Lava, hard, pink; crevice	41	131
Lava, soft, pink	7	138
Lava, hard, gray	17	155
Lava, soft, gray	5	160
Lava, medium soft, gray	15	175
Lava, soft, gray	12	187
Lava, hard, pink	6	193
Lava, soft, burned	32	225
Lava, soft, gray	7	232
Lava, hard, gray	14	246
Lava, hard and soft, gray	10	256
Lava, honeycomb; water struck at 265 feet	25	281
Lava, hard, gray	10	291
Lava, honeycomb; water bearing	9	300
Lava, medium soft, honeycomb	17	317
Lava, hard, gray	23	340

(Water stood 230 feet below surface when drilling ceased.)

7S 23E-25bal. Julion Clawson Farms, Inc., well 3. Log by Raymond R. Commons, driller, obtained by U. S. Geological Survey May 4, 1948.

Material	Thickness (Feet)	Depth (Feet)
Soil and clay	13	13
Rock, black, and boulders	12	25
Lava, red	10	35
Lava, black	25	60
Lava, black and red, and boulders; dry loose ground at 65 feet	15	75
Lava, black, with some red; boulders	10	85
Lava, black and red	10	95
Lava, hard, red and black	5	100
Lava, boulders, red and black	10	110
Lava, red and black, with soft streaks	10	120
Lava, red	10	130
Lava, red and black	5	135
Lava, very hard, gray and black	10	145
[All cuttings lost; dry]	10	155
Lava, red and black	10	165
Lava, black	15	180
Lava, red; loose boulders	10	190
Lava, black and red	25	215
Lava, hard, black	5	220
Lava, black and red	30	250
[All cuttings lost]	5	255
Lava, red	5	260
Lava, black and red	30	290
Lava, red and brown, honeycomb [vesicular]	50	340
Lava, black, glassy	20	360
Lava, black and red	5	365
Lava, dark gray	15	380
Lava, gray, sand [granulated?]	25	405
Clay and gravel, red	10	415
Lava, black and gray	15	430
Lava, black and red; opening with loose mud	5	435
Lava, black and red; lower 5 feet loose	15	450
Lava, black and red	17	467

7S 23E-25ccl. Julion Clawson Farms, Inc., well 2. Log by driller Raymond R. Commons, obtained by U. S. Geological Survey June 9, 1947.

Material	Thickness (Feet)	Depth (Feet)
Soil and clay	32	32
Lava, black, sandy	28	60
Lava, gray, sandy	10	70
Lava, brown	20	90
Lava, brown, black and red; openings at 94 and 115 feet	25	115
Lava, brown and black; opening at 120 feet.	25	140
Lava, red	15	155
Lava, brown	10	165
Lava, brown and red	30	195
Lava, black and red; loose ground[a]	20	215
Lava, rock, black, dry; loose	5	220
Lava, black	35	255
Lava, black and red	15	270
Lava, black; some water	5	275
Lava, black and red	40	315
Lava, black and red; broken ground[a]	5	320
Lava, black	5	325
Lava, black; broken ground	5	330
Lava, black and red; estimated 60% of cuttings lost	5	335
Lava, black and red; estimated 10% of cuttings lost	5	340
Lava, black, some red; estimated 20% of cuttings lost	10	350
Lava, black, some red; estimated 50% of cuttings lost	10	360
Lava, black; estimated 10% of cuttings lost	5	365
Lava, black; estimated 40% of cuttings lost	5	370
Lava, black; estimated 20% of cuttings lost	5	375
Lava, black; estimated 10% of cuttings lost	5	380
Lava, black; all cuttings lost	5	385
Lava, dark gray	5	390
Lava, black; some gray lime with soft streaks	5	395
Lava, black, with soft streaks	5	400
Lost cuttings; struck strong flow of water	10	410

(Tape-line measurement of depth by U. S. Geological Survey June 9, 1947; 411.5 ft.)

a/ From the driller's verbal description of what is called "loose ground" and "broken ground" in the log, it is believed to represent broken-up lava.

7S 23E-26ddl. Julion Clawson Farms, Inc., well 1. Log by driller, Raymond R. Commons, obtained by U. S. Geological Survey June 9, 1947.

Material	Thickness	Depth
	(Feet)	
Soil and sandy clay	23	23
Lava rock, brown and gray	77	100
Lava rock, brown and gray; soft streaks and crevices	30	130
Lava rock, brown	52	182
Lava rock, gray	23	205
Lava rock, red	15	220
Lava rock; soft streaks and crevices	20	240
Lava rock; gray	35	275
Lava rock, black; some water	5	280
Lava rock, spotted brown and black; some crevices	10	290
Lava rock, spotted brown and black; small crevices and mud openings	9	299
Lava rock, brown and gray; water; estimated 60% of cuttings lost	16	315
Sand rock, black and brown; water; estimated 75% of cuttings lost	5	320
Lava rock, black, brown, and red; small opening; estimated 75% of cuttings lost	20	340
All cuttings lost	10	350
Lava rock; about 50% of cuttings lost	17	367
Lava rock, black and brown	13	380
Lava rock, black and brown, some red	3	383

Water stood at 270 feet below surface. Some clay and mud layers were encountered between some of the lava beds.

8S 23E-27bdl. U. S. Bureau of Reclamation well C. Log by driller, Jim Schoonover, obtained by U. S. Geological Survey April 2, 1948. Original terminology slightly modified.

Material	Thickness	Depth
	(Feet)	
Soil, sandy loessial, pale brown to buff	14	14
Lava, vesicular, dark gray (loose cobbles)	3	17
Lava, dark gray	31	48
Lava, reddish gray	3	51
Lava, reddish	28	79
Silt, sand or loess, yellowish red	1	80
Lava, reddish	3	83
Lava, hard, dark bluish gray	18	101
Lava, broken, black	2	103
Lava, black, brown, and reddish	34	137
Lava, hard, blue	15	152
Lava, reddish	Trace	152
Lava, dark bluish gray	16	168
Lava, bluish; some water at 180 feet	12	180
Lava, black; about 75% of cuttings lost; on February 25, when depth was 188 feet, static water level was 178 feet below land surface	10	190
Lava, black and reddish	20	210
Lava, cindery, brick red	5	215
Lava, black to red	10	225
Lava, reddish black; caves badly	10	235
Lava, dark gray to black. Lost about 25% of cuttings from 190 feet to bottom	25	260

8S 24E-36da1. Minidoka Irrigation District drainage well 11. Log from drill foreman's original record in files of Minidoka Irrigation District, Rupert, Idaho

Material	Thickness (Feet)	Depth
Clay	25	25
Lava rock	52	77
Clay, red	3	80
Lava rock	57	137

Struck water at 95 feet and it rose to 90 feet below the surface; open crevices occurred at 115 feet, 117 feet, and 120 feet. A large crevice at 133 feet contained running sand.

8S 25E-1cb1. Union Pacific Railroad Co., Minidoka supply well. Log from water service foreman's original blueprint, obtained from W. B. Groome, Division Superintendent.

Material	Thickness (Feet)	Depth
Began 14-in. hole September 23, 1912.		
Clay	28	28
Lava rock. Set 14-in. casing to 52 feet ..	107	135
Lava, red	25	160
Lava rock. Struck water at 208 feet; stands 16 feet in well [i.e., rose 16 feet to 192 feet below surface]	48	208
Lava rock, water bearing; water stood 208 feet below surface, Oct. 10, 1912	32	240
Lava rock. Struck heavy flow of water at 325 feet. Water stood 190 feet from surface Oct. 12, 1912	85	325
Lava rock. Drillings carried away for period of 33 hours. Water stood at 185 feet Oct. 14, 1912	65	390

8S 25E-32bc1. Minidoka Irrigation District drainage well 12. Log from original records by J. B. Dilts, driller, obtained by U. S. Geological Survey November 1947.

Material	Thickness (Feet)	Depth
Clay	4	4
Lava; 12-inch open crevice at 107 feet; 18-inch open crevice at 109.5 to 111 feet, in which all drill cutting were carried away underground	107	111

8S 25E-32bc2. Minidoka Irrigation District drainage well 9. Log from original records by J. B. Dilts, driller, obtained by U. S. Geological Survey November 1947.

Material	Thickness (Feet)	Depth
Clay	24	24
Lava	24	48
Crevice in lava	0.3	48.3
Lava	8.7	57
Crevice in lava	1.5	58.5
Lava	5.5	64
Crevice in lava	0.3	64.3
Lava	38.7	103

8S 24E-7dal. U. S. Bureau of Reclamation well B. Log by Raymond R. Commons, driller, obtained by U. S. Geological Survey April 2, 1948. Terminology slightly modified.

Material	Thickness (Feet)	Depth (Feet)
Loess and loessial soil, buff to light brown	25	25
Lava, dense, black and dark gray	55	80
Lava, dense, dark gray and brown	5	85
Lava, black and reddish black; caved during drilling	5	90
Lava, dark gray	5	95
Lava, black and reddish; open crevice from 100 to 105 feet; broken rock from 105 to 115 feet	20	115
Lava, dense, solid	15	130
Lava, black and reddish brown; open crevices	10	140
Lava, black and brown; loose and broken	5	145
Lava, black and reddish brown	20	165
Lava, black; indications of water between 170 and 175 feet	10	175
Lava, vesicular, black, brown, and reddish From 185 to 190 feet lost about 50% of cuttings	15	190
Lava, dense, black to brown	10	200
Lava, vesicular, brownish black	5	205
Lava, dense dark gray and brownish black. Depth to water 168 feet, March 12, 1948, when well depth was 240 feet	35	240

8S 24E-11bal. U. S. Bureau of Reclamation well A. Log by Raymond R. Commons, driller, obtained by U. S. Geological Survey April 2, 1948. Terminology slightly modified.

Material	Thickness (Feet)	Depth (Feet)
Soil, loessial, light brown	5	5
Loess and fine drift sand, buff	30	35
Loess and sand, light brown	5	40
Loess and fine sand, brownish gray	3	43
Loess and lava boulders	3	46
Lava, dense, dark gray	19	65
Lava, hard, vesicular, black and reddish; loose lava blocks; caved badly	16	81
Lava, dark gray to light reddish brown	19	100
Lava, black and dark gray; some loose blocks and red zones	20	120
Lava, black and brown, with loess or wind-blown sand	16	136
Lava, black; upper part vesicular	22	158
Lava, black, loose and blocky	2	160
Lava, hard, vesicular, black to brown, with open crevices. Struck water between 165 and 170 feet, lost 25% to 95% of cuttings at various depths. Caved badly from 180 to 190 feet	35	195
Lava, dense black; brown and reddish in lower part; 50% to 90% of cuttings lost.	30	225

9S 22E-33ab1. U. S. Bureau of Reclamation (formerly Corps of Engineers, U. S. Army, Prisoner of War Camp). Log from copy of driller's log in files of City Engineer, Burley, Idaho, obtained by U. S. Geological Survey June 26, 1947.

Material	Thickness (Feet)	Depth
Soil, sand	30	30
Lava cinders	35	65
Lava, hard	15	80
Cinder, red	0+	80+
Lava, black	5	85
Basalt, very hard, gray	65	150
Cinders, red	5	155
Lava, black	77	232
Basalt, gray	9	241
Lava, black	16	257
Lava cinders at bottom		

13 feet of water in well

9S 22E-33ad1. U. S. Bureau of Reclamation (formerly Corps of Engineers, U. S. Army, Prisoner of War Camp). Log from copy of driller's log in files of City Engineer, Burley, Idaho, obtained by U. S. Geological Survey June 26, 1947. U. S. Geological Survey observation well.

Material	Thickness (Feet)	Depth
Soil, sandy, and blow sand	30	30
Blow sand	10	40
Clay, sticky	48	88
Lava, black	27	115
Basalt, very hard, gray	12	127
Basalt, gray	3	130
Lava, porous, red	5	135
Lava, black	10	145
Cinders	85	230
Lava, black	5	235
Lava cinders	13	248
Basalt, gray	9	257
Sand, black, at bottom		

26 feet of water in well

9S 23E-10b?1. Destroyed. Minidoka Irrigation District drainage well 2. Log from original record by J. B. Dilts, driller, obtained by U. S. Geological Survey November 1947.

Material	Thickness (Feet)	Depth
Clay	9	9
Sand and gravel	2	11
Clay	10	21
Lava	87	108

Numerous crevices encountered during drilling; outward draft of air so strong drilling water had to be introduced to bottom of hole with a pipe. [Hole was probably dry when completed].

9S 23E-10bc1. U. S. Bureau of Reclamation. Minidoka Irrigation District drainage well 15. Log from drill foreman's original record in files of Minidoka Irrigation District, Rupert, Idaho, obtained by U. S. Geological Survey November 1947.

Material	Thickness (Feet)	Depth
Clay	17	17
Sand	10	27
Clay	10	37
Lava; 8-inch crevice at 113 feet	81	118
Clay, red	5	123

March 14, 1912. Water stood at 98 feet below land surface.

9S 23E-19a?1. Destroyed; exact location unknown. Minidoka Irrigation District drainage well 7. Log from original record by driller, J. B. Dilts, obtained by U. S. Geological Survey November 1947.

Material	Thickness (Feet)	Depth (Feet)
Clay	10	10
Sand	7	17
Gravel	7	24
Clay	2	26
Lava	49	75
Clay, red	6	81
Lava	35	116

Several cavities struck in lavas.

9S 23E-26cc1. Minidoka Irrigation District miscellaneous well 3. Log from drill foreman's original record in files of Minidoka Irrigation District, Rupert, Idaho, obtained by U. S. Geological Survey November 1947.

Material	Thickness (Feet)	Depth (Feet)
Soil	3.0	3.0
Cemented clay	8.0	11.0
Gravel, compact	24.0	35.0
Clay, blue	15.0	50
Lava	28.2	78.2
Sand, red	9.8	88.0

At 88 feet had 10 feet of water in hole.

9S 23E-27bc1. Amalgamated Sugar Company, Rupert Factory, near Paul. Log from copy furnished to Sugar Company by driller, A. J. Schoonover, obtained by U. S. Geological Survey Nov. 10, 1947.

Material	Thickness (Feet)	Depth (Feet)
Plain sand and clay	18	18
Sand, fine	15	33
Clay	39	72
Sand, fine	31	103
Clay, sandy	20	123
Lava rock and abundance of hard water (Cemented off sand at 154 feet)	31	154
Sand, and much fairly hard water	31	185
Clay, blue	85	270
Clay, white	20	290
Sand, mixed with water	22	312
Clay, blue	58	370
Sand, fine, and much water	22	392
Clay, blue	76	468
Clay, hard, blue	7	475
Clay, blue	11	486
Sand, and some water	2	488
Lava rock	58	546
Sand rock, and water	10	556

10-inch casing from 0 to 338 feet; 8-inch casing from 326 to 498 feet; 10-inch casing is perforated.

9S 24E-1db3. Ira Kent. Log from memory of Henry Boley, former owner, obtained by U. S. Geological Survey May 14, 1948.

Material	Thickness (Feet)	Depth (Feet)
Soil	18	18
Lava	16	34
Clay	31	65
Lava. Main source of water at 75 feet; water rose a little in well after it was struck	27	92
Mud	3	95
Lava	23	118

9S 24E-6da1. U. S. Bureau of Reclamation, Minidoka Irrigation District drainage well 1. Log from original record of drill foreman in files of Minidoka Irrigation District, Rupert, Idaho, obtained by U. S. Geological Survey Nov. 10, 1947.

Material	Thickness (Feet)	Depth
Clay	9	9
Sand and gravel	24	33
Gravel, coarse	6	39
Clay, red	20	59
Clay, white	11	70
Basalt lava	31	101

Main flow of water struck at 100 feet, though there are several crevices higher in the lava that contained considerable water.

9S 24E-6da2. Minidoka Irrigation District drainage well 14. Log from original record of drill foreman in files of Minidoka Irrigation District, Rupert, Idaho, obtained by U. S. Geological Survey Nov. 10, 1947.

Material	Thickness (Feet)	Depth
Sand, with some layers of clay	38	38
Clay	32	70
Lava, loose	14	84
Lava, solid	28.5	112.5

Drill struck a 6-in. crevice at 104 ft. and an 8-inch crevice at 108 feet; at each of these all cuttings were washed away underground.

9S24E-6da3. Minidoka Irrigation District drainage well 13. Log from original record of drill foreman in files of Minidoka Irrigation District, obtained by U. S. Geological Survey Nov. 10, 1947.

Material	Thickness (Feet)	Depth
Not recorded	70	70
Lava	14	84
Lava, loose	2	86

9S 24E-6a4. Minidoka Irrigation District 1929 miscellaneous well 1. Log from original driller's record in files of Minidoka Irrigation District, obtained by U. S. Geological Survey Nov. 10, 1947.

Material	Thickness (Feet)	Depth
Clay, red	60	60
Lava rock	5	65
Struck small amount of water at 65 feet.		

9S 24E-7a?1. Destroyed; exact location unknown. Minidoka Irrigation District drainage well 6. Log from original records by driller, J. B. Dilts, obtained by U. S. Geological Survey, November 1947.

Material	Thickness (Feet)	Depth
Clay	8	8
Sand and gravel	22	30
Gravel, coarse	5	35
Clay, red	40	75
Clay, white	5	80

Lava; 1.5-foot crevice at depth of 84 feet, and 2-foot crevice at 98 feet. Strong outdraft of air after tapping first crevice. Principal water at 98 feet, from which it rose to 80 feet.

9S 24E-28dc1. Destroyed. Minidoka Irrigation District drainage well 8. Log from original record by driller, J. B. Dilts, obtained by U. S. Geological Survey November 1947.

Material	Thickness (Feet)	Depth
Sand	25	25
Clay	53	78
Lava	4	82
Sand	33	115
Lava	9	124
Gravel, coarse; runs into hole	6	130

9S 24E-29ab1. City of Rupert deep well 1. Log from copy of log furnished by driller, A. J. Schoonover, to City Engineer, Rupert, obtained by U. S. Geological Survey Nov. 4, 1947.

Material	Thickness (Feet)	Depth (Feet)
Soil	5	5
Quicksand; water at 8 feet	28	33
Gravel	2	35
Clay, red	5	40
Clay, blue	37	77
Sand	6	83
Clay, blue; 16-inch casing set to 99 feet	16	99
Lava, black; flow of hard water under the rock	60	159
Clay	15	174
Soapstone (?)	15	189
[Not recorded]	3	192
Hardpan	1	193
Clay, red	18	211
Clay, yellow	8	219
Clay, blue. At 258 feet reduced hole to 13 inches	66	285
Hardpan	2	287
Clay	18	305
Sand, gravel, and burned lava	2	307
Sand; flow of water at 305 feet, but in much sand	23	330
Clay, blue	48	378
Sand	2	380
Limestone (?)	2	382
Sand	7	389
Sandstone	9	398
Clay, blue	12	410
Sand	6	416
Gravel	2	418
Sand	35	453
Clay	4	457
Soapstone	21	478
Lava rock, black	8	486
Lava, vesicular, showing signs of water	14	500

Lava, broken; comes out in chunks; finished well at 500 feet with plenty of water. Drove 485 feet of 13-inch casing.

9S 24E-29ab2. City of Rupert, abandoned and destroyed well in public square of Rupert Middle Townsite. Originally drilled for U. S. Bureau of Reclamation and listed as Minidoka Irrigation District miscellaneous well 1. Log from drill foreman's original record in files of Minidoka Irrigation District, Rupert, Idaho, obtained by U. S. Geological Survey Nov. 10, 1947.

Material	Thickness (Feet)	Depth (Feet)
Sand formation	18	18
Gravel, fine, compact, streaked with sand	16	34
Cement, pink	4	38
Clay, yellow	12	50
Clay, blue	35	85
Lava, very hard	10	95
Clay	10	105
Lava	2	107
Gravel	2	109
Lava	5	114

When at depth of 105 feet had 4 feet of water in hole; struck water in gravel at 107 feet; struck water at 114 feet. Well finished at 114 feet with 62 feet of casing [size of casing not known]

9S 24E-29ac1. Union Pacific Railroad Co., Rupert Station. Log from blueprint record of water service foreman, obtained Jan. 14, 1947, by U. S. Bureau of Reclamation from W. H. Groome, Railroad Company Division Superintendent.

Material	Thickness (Feet)	Depth (Feet)
Sand	20	20
Gravel	22	42
Clay	38	80
Sand, black	24	104
Gravel	5	109
Shale, sandy; drove 12-inch casing to 132 feet; struck water in top of lava at 132 feet	23	132
Lava	15	147
Lava, gray, hard	6.5	153.5

Well begun by driving 12-inch casing and bailing unconsolidated materials; later resorted to drill. Finished as 12-inch open hole in lava. Static water level 53.5 feet below surface.

9S 24E-31b?1. Destroyed. Minidoka Irrigation District well 5. Log from original record of driller, J. B. Dilts, obtained by U. S. Geological Survey November 1947.

Material	Thickness (Feet)	Depth (Feet)
Sand	21	21
Sand and gravel	18	39
Clay	10	49
Sand	14	63
Sand and gravel	20	83
Sand	10	93
Clay	3	96
Sand and shells	22	118
Lava	3	121
Sand	2	123
Lava	13	136
Sand, coarse	4	140

Upper sands ran into hole. Static water level on completion 30 feet below land surface, Oct. 14, 1910.

10S 23E-20dc4. City of Burley well 5. Log from record by driller, T. J. Stephenson, obtained by U. S. Geological Survey, 1928. Not previously published or released. Terminology slightly modified, 1947.

Material	Thickness (Feet)	Depth (Feet)
Soil	8	8
Sand and gravel (water level at 10 feet)	12	20
Quicksand	10	30
Clay, soft	8	38
Packed sand and gravel	8	46
Clay and gravel	6	52
Gravel; water	14	66
Clay, soft	6	72
Clay and gravel	18	90
Sand	8	98
Clay, hard	34	132
Cemented stratum	8	140
Clay, soft	4	144
Clay, hard, sandy (24-inch casing with concrete around 18-inch casing landed on lava at 158 feet.)	14	158
Lava, black (At 175 feet water level fell to 52 feet; at 185 feet water level fell to 100 feet; at 197 feet water level fell to 130 feet.)	44	202
Lava, very hard, black	20	222
Lava, black; crevices full of yellow clay	16	238
Lava, black; at 245 feet water level fell to 195 feet	17	255
Clay, sandy, red	13	268
Clay, sticky, yellow	12	280
Talc [probably light-colored clay]	11	291
Gravel, loose	1	292
Clay, hard, yellow	9	301
Sand and gravel; water	15	316
Clay, hard, yellow	69	385
Clay, sticky, blue (At 390 feet, 15-inch casing was cut off and pulled out, leaving a lap of 28 inches in 18-inch casing.)	30	415
Clay, yellow; 18-inch casing stuck	3	418
Clay, sandy, blue	8	426
Clay and gravel (at 452 feet water level rose to 175 feet)	26	452
Loose gravel; soft water; 15-inch casing perforated in gravel from 452 to 464 feet, 10 holes per foot, 5/8 x 3 inches	12	464
Clay, hard, yellow	4	468

Material	Thickness (Feet)	Depth (Feet)
Lava, broken, black (15-inch casing landed on lava at 469 feet; no casing from 469 feet to bottom)	2	470
Lava, hard, black	6	476
Lava, soft, red	3	479
Lava, hard, gray	21	500
Lava, soft, red	7	507
Lava, hard, red (at 515 feet the water level fell to 207 feet)	20	527
Lava, hard, gray	23	550
Lava, soft, red	7	557
Lava, hard, red	13	570
Lava, hard, gray	11	581
Lava, gray green, very hard	40	621
Lava, hard, red (at 650 feet the water level fell to 215 feet)	79	700
Lava, hard, gray	31	731
Lava, red	12	743
Lava, gray	15	758
Lava, gray and clay	4	762
Lava, gray	43	805
Lava, hard, red	6	811
Lava, broken, red	2	813
Lava, gray	35	848
Lava, broken, red	6	854
Lava, gray	24	878
Lava, hard, red	15	893
Lava, broken, gray; caved a little	7	900
Lava, hard, gray	5	905
Lava, black; alternating hard and soft thin strata	24	929
Lava, hard, black	6	935
Lava, black, and clay	3	938
Lava, black	12	950
Lava, hard, gray	6	956
Lava, black, and clay	8	964
Lava, black	7	971
Lava, hard, gray	12	983
Lava, red	11	994
Lava, hard, gray	6	1,000
Lava, black	16	1,016
Lava, hard, gray	11	1,027
Lava, black	5	1,032
Lava, hard, gray	17	1,049
Lava, black and clay	12	1,061
Lava, red	3	1,064
Lava, black	12	1,076

Material	Thickness (Feet)	Depth (Feet)
Lava, broken, red; caved badly	5	1,081
Lava, hard, gray	6	1,087
Lava, soft, red	5	1,092
Lava, hard, gray	8	1,100
Lava, red	7	1,107
Lava, hard, gray	8	1,115

Test Borings

Inquiries concerning subsurface conditions disclosed by test borings at Minidoka Dam site have been numerous. For that reason it is considered advisable to include in this report the logs of the diamond-drill test borings. The borings were made in a line along the axis of the dam site before the dam was built, during the period July 27 to Oct. 17, 1903. The original records of the U. S. Geological Survey drill foreman, A. L. Knight, are in the files of the Minidoka Irrigation District at Rupert, Idaho. The following logs are copied from the original records on Nov. 10, 1947.

Test Hole 1, Minidoka Dam Site, dam line, N. side begun July 27, 1903; completed Aug. 4, 1903.
Surface elevation: 4,216 feet

Material	Thickness (Feet)	Depth (Feet)
Lava, hard, porous	10	10
Lava, hard, compact	17	27
Lava, solid	16	43
Lava, porous, broken	4	47
Lava, porous	1.2	48.2
Sand	0.5	48.7
Lava, porous	2.3	51
Lava, solid	14	65
Lava, porous, soft	14.5	79.5
Lava, medium hard, porous	5.5	85
Lava, solid	3.2	88.2
Lava, hard, solid	19.8	108

[No water recorded in log]

Test Hole 2, Minidoka Dam Site, dam line, N. side. Begun August 5; completed August 13, 1903.
Surface elevation: 4,238 feet.

Material	Thickness (Feet)	Depth
Lava boulders	12	12
Sand	15.5	27.5
Lava, soft, porous	13.2	40.7
Sand	0.8	41.5
Lava, porous, soft	1.5	43
Lava, medium, soft	5	48
Lava, solid, hard	11	59
Lava, porous, soft	7.2	66.2
Hole in lava	0.5	66.7
Lava, soft, porous	12.1	78.8
Lava, soft	1.2	80

/No water recorded in log/

Test Hole 3, Minidoka Dam Site, dam line, N. side. Drilled August 14-21, 1903.
Surface elevation: 4,246 feet.

Material	Thickness (Feet)	Depth
Lava, solid	8.3	8.3
Sand	2.5	10.8
Hard porous lava boulder	5.9	16.7
Sand, with scattering small boulders	13.3	30

/No water recorded in log/

Test Hole 4, Minidoka Dam Site, dam line, N. side. Drilled Aug. 22 to Sept. 6, 1903.
Surface elevation: 4,196.5 feet.

Material	Thickness (Feet)	Depth
Water	24.5	24.5
Gravel	1.3	25.8
Lava boulder	4.2	30
Gravel	1	31
Lava, soft, porous	6.5	37.5
Lava, hard, porous	1.5	39
Lava, hard, solid	4	43
Lava, hard, porous	3	46
Lava, hard, solid	12	58

(Drilled from barge on river; total rock drilled: 33.5 feet)
/No ground water recorded in log/

Test Hole 5, Minidoka Dam Site, dam line in river bottom. Bored Sept. 8-11, 1903.
Surface elevation: 4,196.5 feet.

Material	Thickness (Feet)	Depth
Water	4.2	4.2
Lava, soft, porous	6.3	10.5
Lava, hard, solid	33.5	44
Lava, porous, soft	3.5	47.5
Lava, solid, compact	32.5	80

Total rock drilled: 75.8 feet

Test Hole 6, Minidoka Dam Site, dam line in river bottom. Bored Sept. 14, 1903.
Surface elevation of water: 4,196.8 feet.

Material	Thickness (Feet)	Depth (Feet)
Water	10	10
Lava, solid	11	21
Lava, medium soft, very porous	6.5	27.5
Lava, solid	2.5	30
Lava, medium soft, very porous	11	41
Lava, compact, solid	5	46
Lava, hard, porous	3	49
Lava, hard, solid	1	50
Lava, hard, solid, very compact	30	80

Total rock drilled: 70 feet

Test Hole 7, Minidoka Dam Site, dam line in river bottom. Bored Sept. 17-22, 1903.
Surface elevation of water not recorded.

Material	Thickness (Feet)	Depth (Feet)
Water	7	7
Lava, soft, porous	4	11
Lava, fairly solid	1	12
Lava, hard, solid	13	25
Lava, porous, solid	16	41
Clay, yellowish; too soft to core	1.8	42.8
Lava, hard, porous	8.2	51
Lava, hard, solid	29	80

Total rock drilled: 73 feet

Test Hole 8, Minidoka Dam Site, dam line in river bottom. Bored Sept. 23-26, 1903.
Water surface elevation: 4,197.7 feet.

Material	Thickness (Feet)	Depth (Feet)
Water	3	3
Lava, solid	3	6
Lava, soft, porous	4	10
Lava, hard, porous	2	12
Lava, hard, solid	8	20
Lava, rotten, soft and porous	4	24
Lava, hard, solid	8	32
Lava, porous	3	35
Lava, hard, solid	2	37
Lava, medium soft, porous	5	42
Lava, solid	2	44
Lava, very soft, rotten	2	46
Lava, porous but fairly hard	4	50
Lava, hard, solid	30	80

Total rock drilled: 77 feet

Test Hole 9, Minidoka Dam Site, dam line in river bottom. Bored Sept. 26-30, 1903.
Water surface elevation: 4,197.7 feet.

Material	Thickness (Feet)	Depth (Feet)
Water	3	3
Lava, hard, solid	3	6
Lava, porous, soft	2	8
Lava, solid	5	13
Lava, hard, solid	12	25
Lava, porous, soft	10	35
Lava, solid	9	44
Lava, porous, soft	1	45
Lava, porous, hard	5.5	50.5
Lava, hard, solid	29.5	80

Total rock drilled: 77 feet

Test Hole 10, Minidoka Dam Site, dam line in river bottom. Bored Oct. 1-3, 1903.
Water surface elevation: 4,197.74 feet.

Material	Thickness (Feet)	Depth
Water	2	2
Lava, solid	11	13
Lava, soft, porous	2.5	15.5
Lava, hard, solid	3.5	19
Lava, soft, porous	3	22
Lava, hard, porous	1.5	23.5
Lava, hard, solid	4	27.5
Lava, soft, porous	4.5	32
Lava, medium soft	5	37
Lava, hard, solid	2	39
Lava, soft, porous	5.5	44.5
Lava, hard, solid	35.5	80

Total rock drilled: 78 feet

Test Hole 11, Minidoka Dam Site, dam line in river bottom. Bored Oct. 5-8, 1903.
Water surface elevation: 4,197.7 feet.

Material	Thickness (Feet)	Depth
Water	2	2
Lava, compact, solid	9	11
Lava, soft, porous	2	13
Lava, compact, solid	3.5	16.5
Lava, hard, porous	6.5	23
Lava, compact, solid	7	30
Lava, porous	4	34
Lava, solid, close-grained	2	36
Lava, very porous	11	47
Lava, very solid, compact	33	80

Total rock drilled: 78 feet

Test Hole 12, Minidoka Dam Site, dam line, S. side. Bored Oct. 9-14, 1903.
Surface elevation not recorded.

Material	Thickness (Feet)	Depth
Lava, fairly solid	10	10
Lava, solid, but shown to be along a seam ..	3	13
Lava, solid	12	25
Lava, soft, porous	10	35
Lava, solid	22	57
Lava, very soft, porous	4	61
Lava, compact, solid	6	67
Lava, soft, porous	13	80

Test Hole 13, Minidoka Dam Site, dam line, S. side. Bored Oct. 14-17, 1903.
Surface elevation: 4,228.9 feet.

Material	Thickness (Feet)	Depth
Boulders and gravel	7	7
Lava, medium porous	5	12
Lava, very porous	6	18
Lava, medium porous	3	21
Lava, medium soft and very porous	7	28
Lava, hard, fairly solid	11	39
Lava, porous	5	44
Lava, hard, compact	5	49
Lava, hard, porous	1.5	50.5
Lava, solid, hard	3.5	54
Lava, porous	10	64
Lava, soft, porous	2	66
Lava, solid	7	73
Lava, soft, porous	2	75
Lava, hard, porous	5	80

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GEOLOGICAL SURVEY

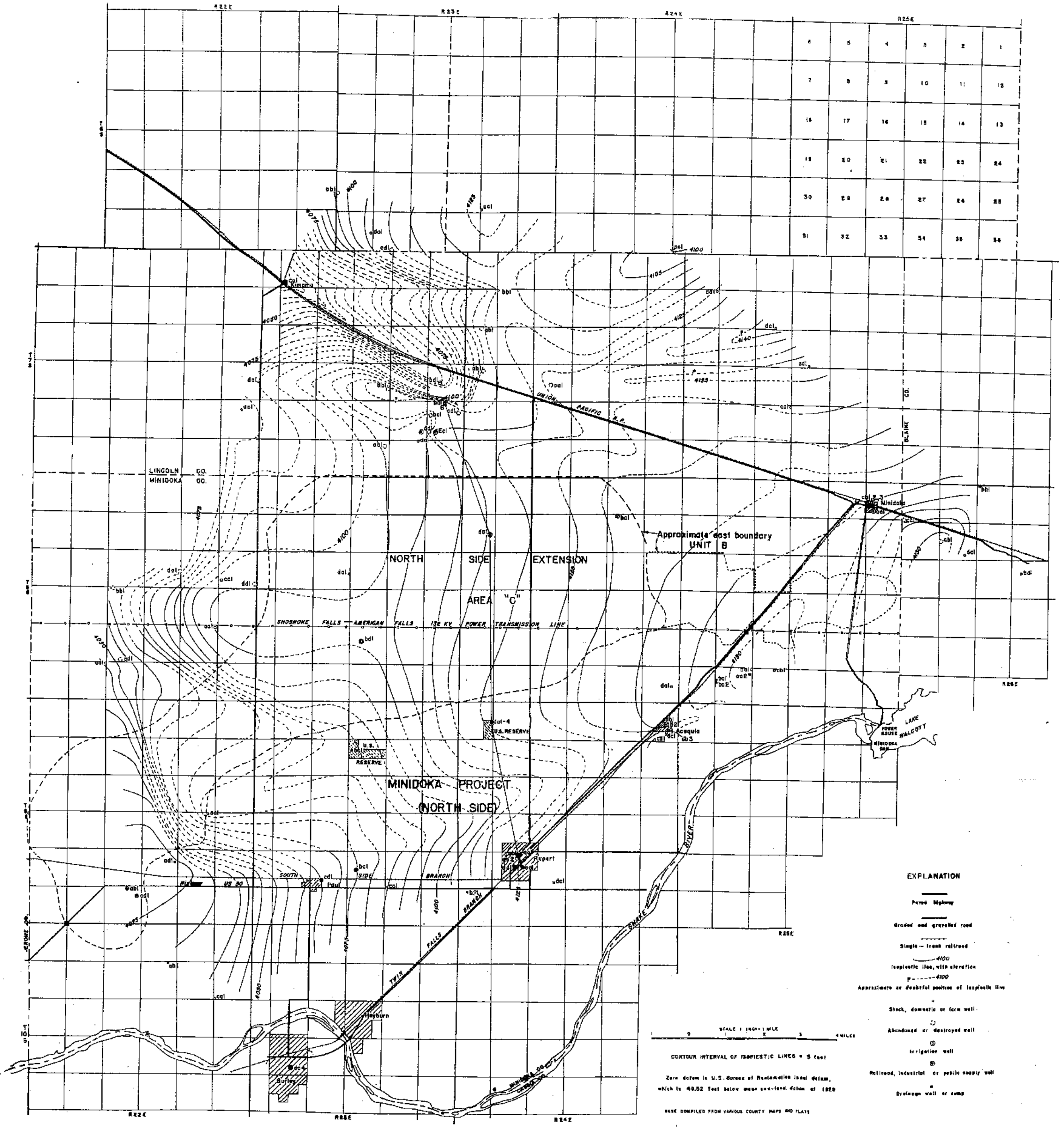

PLATE I. RECONNAISSANCE HYDROLOGIC MAP OF SOUTHERN MINIDOKA COUNTY AND VICINITY, IDAHO

A&B 1239

Table 3. Records of Wells in Minidoka County and adjacent areas, Idaho

Number of well	Owner	Driller	Year completed	Surface elevation (feet)	Depth (feet)	Diameter (inches)	Depth of casing (feet)	Depth to principal aquifer (feet)	Static water level: Depth below surface (feet)	Static water level: Date of Measurement
6S 23E-										
26ccl	Ludwig Mahler	—	Old	4489.2	377.5	6	—	—	360.6	Nov. 4, 1947
30cbl	J. A. Winter	—	Old	4325.1	*234	6	—	—	229.4	June 20, 1928
31dal	C. Stockberger	—	Old	4399.5	301	6	—	—	290.7	Nov. 4, 1947
32cdl	Jack Roth	—	Old	4446.8	—	6	—	—	254.3	June 20, 1928
6S 24E-										
34ccl	Montgomery Bros.	—	Old	4358.7	*270	6	—	—	258.0	June 14, 1928
7S 22E-										
24dal	J. F. Springer	—	Old	4360.5	285	6	—	—	270.4	June 20, 1928
25acl	J. D. Fortune	—	Old	4363.5	286	6	—	—	282.0	June 20, 1928
7S 23E-										
5ccl	U. P. RR Co. well	—	Old	4310.4	*330	8	—	291±	280.0	June 20, 1928
22dal	J. Clawson Farms	—	Old	4396.8	—	6	—	—	271.0	June 20, 1928
24bdl	J. Clawson Farms	—	Old	*4342.9	295	—	—	—	278.5	June 19, 1928
25adl	J. Clawson Farms	—	Old	*4377.9	—	—	—	—	263.9	June 19, 1928
25bal	J. Clawson Farms	R. R. Commons	1947	4392.1	*467	21	20	270±	274.4	June 24, 1947
25bcl	J. Clawson Farms	—	Old	*4380.4	—	—	—	—	269.3	June 19, 1928
25ccl	J. Clawson Farms	R. R. Commons	1947	4380.0	*410	21	35	335±	260.3	June 9, 1947
26ddl	J. Clawson Farms	R. R. Commons	1947	4377.6	*383	21	30	315±	272	June 9, 1947
34aal	J. Clawson Farms	—	Old	*4366.9	—	—	—	—	262.3	Nov. 14, 1928
35aal	J. Clawson Farms	—	Old	4368.4	*283	6	—	—	259.7	June 19, 1928
7S 24E-										
8bbl	Henry Schnabel	—	Old	4430.9	—	—	—	—	314.7	June 14, 1928
18abl	Phillip Gehrig	—	Old	4450.6	—	8	—	—	335.0	June 19, 1928
19abl	J. Clawson Farms	—	Old	4397.1	—	—	—	—	283.7	June 19, 1928
21cal	Andrew Dietz	—	Old	4342.2	—	4	—	—	214.8	June 19, 1928
7S 25E-										
7aal	Joe E. Bill	J. W. McAllister	—	4434.6	*400±	8	—	—	307.7	June 14, 1928
9dcl	Montgomery Bros.	—	1913	4364.9	247	6	—	—	222.0	Nov. 8, 1947
15cdl	Dan Lindauer	J. W. McAllister (?)	1913	4384.8	302	6	—	—	262.7	Nov. 8, 1947
28aal	Dan Lindauer	J. W. McAllister (?)	1914	4386.9	*270	6	—	—	*230	November 1947
8S 22E-										
13ccl	Adolph Kock	Axel Blumberg	1919	4426.0	*335	6	334	*335	322.4	Oct. 30, 1947
13ddl	Andrew Serr	—	—	4361.1	266	6	—	—	257.0	June 20, 1928
15dal	Mrs. J. Wagerman	Frank Lock	1918	4475.7	418	6	—	—	*403	November 1928
21bbl	George Sukan	J. B. Dilts	—	4529.8	490	4	—	—	*467	November 1928
26aal	Adolph Kock	Frank Lock	1919	4417.3	*335	6	330?	330?	309.1	Oct. 30, 1947
28cdl	Davis Green	J. B. Dilts	1918	4401.3	*350	—	—	—	*343	—
32aal	Adolph Kock	John Lock	1918	4387.0	360	6	—	—	340.5	Nov. 6, 1947

See footnotes at end of table.

Elevation (feet)	Use of well[a]	
4128.6	St.	
4095.7	Dest.	Casing filled
4108.8	Aband.	
4192.5	Aband.	Casing obstru
4100.7	Aband.	Casing filled
4090.1	Aband.	Casing obstru
4081.5	Dest.	Well now fill
4030.4	R. R.	Well at Kiman
4125.8	Dest.	Casing obstru
*4064.4	Dest.?	Could not fin
*4114.0	Dest.?	Could not fin
4117.7	Irr.	New well; not
*4111.1	Dest.?	Could not fin
4119.7	Irr.	New well; not
4105.6	Irr.	Depth to wate well; has b pumped.
*4104.6	Aband.	Could not fin
4108.7	Dom.	
4116.2	St.	Could not en
4115.6	Aband.	Casing obstr
4113.4	Dest.	Found destro
4127.4	Dest.	Casing obstr
4126.9	St.	
4142.9	St.	
4122.1	St.	Casing wet; is approxi
*4156.9	St.	
4103.6	St.	Water at 335 feet when
4104.1	Dest.	Found filled
*4072.7	Aband.	Casing obstr
*4062.3	Aband.	Casing obstr
4108.2	St.	
*4057.3	Dest.	Abandoned an
4046.5	None	Well capped;

Table 3 (Continued)

Number of well	Owner	Driller	Year completed	Surface elevation (feet)	Depth (feet)	Diameter (inches)	Depth of casing (feet)	Depth to principal aquifer (feet)	Static water level: Depth below surface (feet)	Static water level: Date of Measurement	Static water level: Elevation (feet)	Use of well[a]	
8S 23E-													
16dal	Mrs. G. Montgomery												
27bdl	U. S. Bureau of Reclamation	J. W. McAllister	1920	4291.3	199	8	—	—	187.9	Oct. 30, 1947	4103.4	St.	Measured dep
8S 24E-													Reported to
7dal	U. S. Bureau of Reclamation	Jim Schoonover	1948	4284.5	260	20	21	190	179.0	March 11, 1948	4105.5	Irr.	Test pumped
11bal	U. S. Bureau of Reclamation												
36dal	Minidoka Irrig. District	R. R. Commons	1948	4278.1	240	20	31	185	168.5	April 23, 1948	4109.6	Irr.	Test pumped
8S 25E-		R. R. Commons	1948	4300.6	225	20	50	180±	166.4	March 10, 1948	4134.2	Irr.	Test pumped
1cbl	U. P. R. R. Co.	J. B. Dilts	1910	4193.7	*137	—	—	95	*90	Jan. 8, 1910	*4103.7	Drain.	Drainage wel
1cb2	U. P. R. R. Co.	Pennsylvania Drill-						208 &					
		ing & Constr. Co.	1912	4332.2	*390	12	52	325	175.5	June 16, 1928	4156.7	R. R.	Water is so
		—	—	4330.9	277	6	—	—	192.9	Oct. 31, 1947	4138.0	None	6-inch open
1cb3	U. P. R. R. Co.								(See remarks)				Two nearby
1ccl	Minidoka Village												time of we
32aal	Joe E. Bill	Louis Deppe	—	4330.9	*390±	12	—	—	*190	1943	4140.8	R. R.	Water is so
32aa2	Joe E. Bill	J. W. McAllister	1922	4330.2	282	6	20±	—	183.8	Oct. 31, 1947	4146.4	P. S.	Furnishes pu
		J. W. McAllister	1935	4219.0	*110	6	20	100±	*85	1935	*4134	Dom.	
32bcl	Minidoka Irrig. District	J. W. McAllister	1935	4216.0	72.5	6	—	65±	63.1	Oct. 31, 1947	4152.9	Drain.	6-inch uncas
32bc2	Minidoka Irrig. District												depth repo
33abl	E. L. Aker	J. B. Dilts	1912	—	—	—	—	109	*75	Sept. 13, 1912	—	Drain.	Minidoka Irr
8S 26E-		—	1910	—	*103	6	—	85±	*83.5	Nov. 28, 1910	—	Drain.	Minidoka Irr
4bbl	Blaine Co. School Board	J. W. McAllister	1927	4227.7	95.5	6	20±	78	74.4	Oct. 31, 1947	4153.3	Dom.	
6ccl	W. E. Swengel												
8cbl	—	—	1915	4378.0	256	8	—	—	229.9	Nov. 8, 1947	4148.1	School	
8dcl	H. Ratschkowst	—	—	4353.9	231	6	—	—	217.5	June 15, 1928	4136.4	Aband.	Casing obstr
15bdl	—	—	—	4332.6	—	6	—	—	207.0	June 16, 1928	4125.6	Aband.	
9S 22E-		—	—	4342.0	209	—	—	—	204.5	June 16, 1928	4137.5	St.	
23aal	Howard Easton	—	—	—	—	4	—	—	172.6	May 13, 1948	—	St.	
27adl	Harry Serr												
33abl	U. S. Bureau of Reclamation	John Dill	1913	4221.1	*202	6	73	200	*138	Spring, 1945	*4083.1	St. & Dom.	
33adl	U. S. Bureau of Reclamation	John Dill	Old	4211.1	230	6 - 4	230±	230	188.8	Nov. 3, 1947	4022.3	Dom.	
9S 23E-		Paul Vollmer	1944	4244.0	*257	12	—	—	224.5	Oct. 30, 1947	4019.5	Obs.	Formerly sup
10b?1	—	Paul Vollmer	1944	4250.4	252.5	12	90±	230±	227.5	Oct. 30, 1947	4022.9	Obs.	Formerly sup
		J. B. Dilts	1910	—	108	—	—	—	?Dry?	—	—	Dest.	Cannot be fo
10bcl	U. S. Bureau of Reclamation												cation as
19a?1	Minidoka Irrig. District												drainage w
		J. B. Dilts	1912	4183.7	123	—	—	100±	*91	Sept. 23, 1912	*4092.7	Drain.	Located at G
		J. B. Dilts	1910	—	116	—	—	100±	*100	Oct. 31, 1910	—	Dest.	Cannot be fo
26ccl	Minidoka Irrig. District												cation as
27bcl	Amalgamated Sugar Co.												drainage w
28cdl	Paul Village	John E. Badley	1905	4189.9	* 88	—	—	88	*78.0	May 19, 1905	*4111.9	Dest.	Cannot be fo
		A. J. Schoonover	1941	4195.8	*556	10	498	498	*121.5	1944	*4074.3	Dom.	Supplies dri
		A. J. Schoonover	1917	4189.5	*300	8	—	—	*125	—	4064.5	P. S.	Furnishes pu

See footnotes at end of table.

Table 3 (Continued)

Number of well	Owner	Driller	Year completed	Surface elevation (feet)	Depth (feet)	Diameter (inches)	Depth of casing (feet)	Depth to principal aquifer (feet)	Static water level: Depth below surface (feet)	Static water level: Date of Measurement	Static water level: Elevation (feet)	Use of well[a]	
9S 24E-													
1cd1	Mrs. J. W. McAllister	J. W. McAllister	1918	4203.9	*87	6	40	65±	*65	1947	*4138.9	Dom.	
1db1	V. L. Comstock	J. W. McAllister	—	4204.0	*96	6	—	—	*63	1947	4141.0	Dom.	
1db2	Louis Madrid	J. W. McAllister	—	4203.1	87.5	6	—	—	60.8	Oct. 31, 1947	4142.3	Dom.	
1db3	Ira Kent	J. W. McAllister	1922	—	*118	6		75	62.2	May 14, 1948	—	Dom. & St.	
1dc1	Acequia School District	—	1917	4203.0	* 92	6	—	—	61.1	Oct. 17, 1927	4141.9	Dom.	Four drainage (s
6da1-4	U. S. Bureau of Reclamation	J. B. Dilts	1910	4185.8	* 65-112	6	70-84	100-104	*89	Feb. 29, 1912	*4096.8	Drain.	site; three no
7a?1	Minidoka Irrig. District	J. B. Dilts	1910	—	*101	—	—	—	*80.0	Dec. 2, 1910	—	Dest.	Cannot be found; as E½ NE¼, sec
28dc1	Minidoka Irrig. District	J. B. Dilts	1910	—	*130	6	115	—	—	—	—	Dest.	Unsuccessful dra
29aa1	City of Rupert	—	1916	—	* 31	144	31	6±	5.5	June 10, 1947	—	P. S.	Stand-by public water in Quate
29ab1	City of Rupert	A. J. Schoonover	1939	4205.6	*500	16-13	485	486	*82-95	May 7, 1940 to June 10, 1947	*4110 to *4123	P. S.	Main supply well
29ab2	City of Rupert	John E. Badley	1905	4208	114	—	62	109	*101	January, 1905	*4107	Dest.	Former public we Middle Townsite
29ac1	U. P. R. R. Co.	Pennsylvania Drilling & Constr. Co.	1914	—	*153.5	12	132	132	*53.5	March 15, 1914	—	None	Former R. R. sup
29ad1	City of Rupert	R. R. Commons	Inc.	4205±	615	20-16	615	—	—	—	—	P. S.	New proposed publ all water above
31b?1	Minidoka Irrig. District	J. B. Dilts	1910	4189±	140	6	118	123	*30±	Oct. 14, 1910	*4159±	Dest.	Unsuccessful dra location as S½
10S 22E-													
12cc1	School District No. 11	—	—	4208.6	194	4	—		170.6	Nov. 1, 1947	4038.0	School	
15ab1	—	J. B. Dilts	1910	—	—	—	—	—	—	—	—	Dest.	Used for domestic now destroyed.
10S 23E-													
20dc4	City of Burley	Roscoe Moss & Co.	1926	—	1,115	24-15	469	452	189.4	March 11, 1948	—	P. S.	Furnishes public

*Designates reported depths of wells, depths to static water levels, and elevations; these are only approximate.

[a] Aband., abandoned; Dest., destroyed; Dom., domestic; Drain., drainage; Irr., irrigation; P. S., public supply; St., stock.

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